VOLUME V.
NUMBER 19.

[COPYRIGHT, 1888.]

SEPTEMBER, 1888.

Annual Subscriptions to Institutions $5.00.
Single Copies - 50 cts.

TRANSACTIONS

OF THE

AMERICAN INSTITUTE

OF

ELECTRICAL ENGINEERS.

SPECIAL MEETING, OCTOBER 9TH, 1888.

SUBJECT:

Some Objections to the Overhead Conductor for Electric Railways.

By M. R. LEONARD.

Note on Gearing for Electric Railway Motors.

By ALMON ROBINSON.

(A discussion of the paper, read June 19th, on the Solution of the Rapid Transit Problem.)

NEW YORK CITY:

PUBLISHED BY THE INSTITUTE UNDER THE SUPERVISION OF THE EDITING COMMITTEE.

R. W. PEAKE, Secretary,

TEMPLE COURT, 5 BEEKMAN STREET.

OFFICERS AND MEMBERS OF THE COUNCIL.

1888-9.

PRESIDENT:

EDWARD WESTON,
Term expires 1889.

PAST-PRESIDENTS:

DR. NORVIN GREEN, 1884-5-6. FRANKLIN L. POPE, 1886-7.
T. COMMERFORD MARTIN, 1887-8.

VICE-PRESIDENTS:

FRANKLIN L. POPE,
Term expires 1889.

Prof. ELIHU THOMSON,
Term expires 1890.

Col. ROWLAND K. HAZARD,
Term expires 1889.

FRANCIS R. UPTON,
Term expires 1890.

Prof. W. A. ANTHONY,
Term expires 1889.

T. COMMERFORD MARTIN,
Term expires 1890.

MANAGERS:

Dr. F. BENEDICT HERZOG,
Term expires 1889.

A. C. FOWLER,
Term expires 1890.

Captain O. E. MICHAELIS, U.S.A.
Term expires 1889.

JOHN W. HOWELL,
Term expires 1890.

Prof. CYRUS F. BRACKETT,
Term expires 1889.

CHARLES CUTTER,
Term expires 1891.

C. O. MAILLOUX,
Term expires 1889.

GEORGE H. PRESCOTT, Jr.,
Term expires 1891.

Dr. SCHUYLER S. WHEELER,
Term expires 1889.

THOMAS D. LOCKWOOD,
Term expires 1891.

JOSEPH WETZLER,
Term expires 1890.

WILLIAM MAVER, Jr.,
Term expires 1891.

TREASURER:

GEORGE M. PHELPS,
11 Wall Street, New York.

SECRETARY:

RALPH W. POPE,
5 Beekman Street, New York.

Terms expire 1889.

BOARD OF EXAMINERS.

W. B. VANSIZE, Chairman.

F. W. JONES, E. T. BIRDSALL,
F. R. CROCKER, EDWARD P. THOMPSON.

Standing Committees appointed by direction of Council:

Editing and Library Committee.

GEORGE A. HAMILTON, } Editing.
FRANKLIN L. POPE, }
FRANCIS R. CROCKER, }

JO. STANFORD BROWN, }
GEORGE I. RHEINVILLE, } Library.
GEORGE H. STOCKBRIDGE. }

Committee on Membership, etc.

RALPH W. POPE, Chairman.

THOMAS D. LOCKWOOD, Local Secretary, Boston, Mass.
Dr. LOUIS DUNCAN, " " Baltimore, Md.
CARL HERING, " " Philadelphia, Pa.
H. WALLIS CHASE, " " Chicago, Ill.
Prof. EDWARD L. NICHOLS, " " Ithaca, N. Y.
Prof. W. A. ANTHONY, " " Manchester, O.
JOSEPH WETZLER, New York.
J. B. TALTAVALL, " "

Committee on Finance, Building and Permanent Quarters.

GEORGE A. HAMILTON, Chairman.
Captain O. E. MICHAELIS, U.S.A. T. COMMERFORD MARTIN.

Codex of the Rules, applications blanks, [illegible] and general information regarding the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

VOL. V. New York, September, 1888. No. 12.

SECRETARY'S BULLETIN.

The regular monthly meeting of Council was held at No. 5 Beekman Street, on Tuesday, October 2d.

The following named gentlemen were elected to Associate membership:

H. O. Woodruff, Des Moines, Iowa.
John D. Ihlder, Yonkers, New York.

Upon recommendation of the Board of Examiners, the following Associate Members were transferred to full membership:

H. M. Byllesby, Pittsburg, Pa.
W. S. Turner, New York.

The following named gentlemen were added to the Committee on Library and Editing, to act in the capacity of a Library Committee:

Jo. Stanford Brown, Brooklyn, N. Y.
Georges d'Infreville, New York, N. Y.
George H. Stockbridge, New York, N. Y.

The following named gentlemen were added to the Committee on Permanent Quarters; to be known hereafter as the Committee on Finance, Building and Permanent Quarters:

Francis R. Upton, Harrison, N. J.
Thomas A. Edison, Orange, N. J.

The following named gentlemen were appointed to serve on the new Committee on Papers and Meetings:

T. C. Martin, New York.
George M. Phelps, New York.
John W. Howell, New York.
Hubert Howson, New York.
Dr. Schuyler S. Wheeler, New York.

The following named gentlemen were appointed to serve as Local Secretaries in their respective localities, and as a Committee on Membership, etc.:

Ralph W. Pope, New York.
Thomas D. Lockwood, Boston, Mass.
Dr. Louis Duncan, Baltimore, Md.
Prof. Edward L. Nichols, Ithaca, N. Y.
Carl Hering, Philadelphia, Pa.
Joseph Wetzler, New York.
J. B. Taltavall, New York.
Prof. W. A. Anthony, Manchester, Conn.
H. Ward Leonard, Chicago, Ill.

The 30th meeting of the Institute will be held at the College of the City of New York, No. 17 Lexington Avenue, on December 18th, when a paper will be read by W. J. Jenks, Director, Standardizing Bureau of the Edison Electric Light Co., on "Six Years Experience with the Edison Chemical Meter."

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Special Meeting.

The twenty-eighth meeting of the Institute was held at the House of the American Society of Civil Engineers, No. 127 East 23d Street, on Tuesday, October 9th, 1888.

The meeting was called to order at 8 P. M. by Secretary Ralph W. Pope.

The Secretary:—In the absence of the President, the indisposition of one of the Vice-Presidents and the objection of another one to serve this evening, it will be incumbent upon you to select a Chairman, and I am ready to receive nominations for a Chairman, *pro tem* for the evening.

Upon motion of Mr. Wetzler it was voted that Mr. George M. Phelps act as chairman for the evening, and he took the chair accordingly.

The Chairman:—Gentlemen, I am indebted to you for the compliment of being called on to preside to-night. I will ask the Secretary to state the programme for this evening.

The Secretary.—As most of you are aware, the business of the evening, as stated in the call issued, is the discussion of the paper read by Frank J. Sprague before the Institute on June 19th. On account of the length of the paper it was deemed wise to defer the discussion until this fall, and in considering the advisability of taking it up this evening, the council decided that as we had a member in Richmond who had taken great interest in the work to which Mr. Sprague referred, and was in an entirely independent and unbiased position, he would be able probably to give us some valuable information in regard to the work done. In addition to Mr. Leonard's contribution to the discussion, I have a note from Mr. Almon Robinson, Lewiston, Maine, which will also be read, in regard to gearing.

SOME OBJECTIONS TO THE OVERHEAD CONDUCTOR FOR ELECTRIC RAILWAYS.

BY M. B. LEONARD.

Of all the valuable papers read before the Institute, probably none has excited greater interest than Mr. Sprague's admirable contribution on "Electric Railways, the Solution of the Municipal Rapid Transit Problem," in which the advantages of electricity in practical operation have been so well set forth as to convince the most skeptical, of its superiority over all other methods of traction for this class of traffic. Although the paper was written with special reference to the adaptability of electricity in solving the problem of rapid transit in the great city of New York, the benefits resulting from this system of propulsion may be obtained equally as well elsewhere, and prove to be as permanent as we have found them in our own historic city of Richmond.

To electrical engineers this comparatively new application of the electric current, is one of the most important questions that have come before them, and should be carefully studied in all its details, so that the defects and objections may be pointed out and provided against, and the most perfect methods developed as speedily and fully as possible. But in working this question out, it must be remembered that "the more haste, the less speed," and that before undertaking to surpass the locomotive, it is wiser to prove its superiority over the horse or mule. Having accomplished this successfully, then it is time to endeavor to rival steam In attempting what have been aptly described as "feats of sensational engineering," it should always be borne in mind, that failure inevitably deals a severe blow to the whole cause of electric traction, the general public not being always inclined to discriminate in such cases, as will be remembered from the accident which occurred to a number of capitalists and prominent people some years ago who were engaged in testing the traction system of a well-known electrician.

A second point of the utmost importance, is the necessity for first-class workmanship. Anything worth doing at all is worth doing well, and particularly is this the case with the utilization and development on a large scale of a new force. This is so self-evident as to require no further comment.

While it has been successfully demonstrated in the city of Richmond that electric traction is really the solution of the rapid transit problem, and we have felt in the increased value of real estate, and the growth of our city in population, and reputation, the substantial benefits resulting therefrom, I have considered from my daily observation of the operation of this electric road, that the overhead wire system cannot be made a perfect or ideal method of operation under all circumstances, because of the defects inherent in such a method. But that it will serve as a pioneer in the new field, to be supplanted in time by a more perfect system, I have not the least doubt, and in the following remarks I will endeavor to show some of the objections that have come to my notice, although there may be others that have escaped my attention owing to the extreme reticence of all parties connected with the enterprise, doubtless from business reasons.

Of the three most commonly used, the overhead system appears to be the favorite. The latest report of electric street railways in operation in America, showing that out of a total of forty-three, not less than thirty-six are using the overhead system, and that at least thirty, now under construction, have arranged to do so. Doubtless the smaller cost, as compared with the other two, was an important factor in deciding so largely in favor of the overhead conductor.

As used in Richmond, the details of operation have been shown so fully and clearly in Mr. Sprague's paper, that it is unnecessary to repeat them here, beyond stating that the rail and earth system is adopted in connection with the overhead wire.

During the seven months of active operation of the Richmond Union Passenger Railway, many thousand passengers have been successfully transported every day, and at a very much lower cost than could possibly have been done by horse power, owing to the excessive grades encountered, but the defects of the overhead system are now becoming more apparent as the plant suffers its natural depreciation, and we are now in a better position to judge of its value as a permanent institution than we could possibly have done heretofore.

It is an undisputed fact that the encumbering of the streets with the poles required for the overhead system is one of the most serious objections to its use, although they are hidden to a large extent in many places by the shade trees and foliage. Yet on the main streets of our cities where this system is most likely to be used they are not only a grievous eyesore, but also increase the liability to accident from runaway horses and other causes. Their appearance would not perhaps be so offensive were it possible for them to maintain an erect position, but on account of the weight of the trolley wires, and the pressure of the trolley, the tops of the poles are constantly pulled together, notwithstanding they may have at first been raked in the other direction, and thus the unsightly effect is augmented.

Those of us who are acquainted with telegraph line construction can appreciate the great leverage exerted by a heavy strain on the top of a pole twenty-five or thirty feet high unsupported by guys or otherwise, and will readily understand that it is only a question of time before the poles must be reset or replaced with heavier ones. This has been especially the case on the curves where the strains have been greatest, in some instances approximating a pull of 650 lbs. Nor does the net work of wires; span, trolley, guard and curve, inspire the public with any feeling of toleration for the disfiguring of its streets, but must hasten the time when the clamor for underground wires will compel their removal.

But to my mind the most serious objection is the employment of the bare trolley wire carrying a current of 500 volts and about 90 amperes, which I consider not only dangerous to life on account of the frequent breakages of the wire—which on one occasion last spring in falling struck and killed a horse—but also in damage to property by fire. It is claimed that the use of guard wires will always prevent the possibilities of such an occurrence, but the guard wires did not obviate the burning and melting of the telephone wires when on one occasion the breaking of an exchange telephone pole threw them across the trolley wire, and it was necessary to shut down the railway to prevent the entire destruction of the exchange and possibly the firing of the subscribers instruments and houses.

That the trolley wire is liable to breakage at anytime has been shown twice during the past week to the interruption of travel and dissatisfaction of the public. While not so very long ago the

wires over one of the curves were pulled down on top of the car by the trolley catching in it, and travel entirely suspended on that part of the line for one or two days.

A very serious defect in the use of the bare trolley wire is the difficulty of securing proper insulation. Thus far porcelain knobs seem to have been found best adapted for this purpose, and the leakage resulting especially in damp or rainy weather must be considerable on the whole length of the line, and must cause a large waste of current. This is probably the reason why it has been impracticable to run over about thirty cars at one time out of the forty with which the road is equipped, and would seem to indicate a very large loss of energy.

In view of the fact that porcelain insulators have been long ago condemned for telegraph purposes where a comparatively small current is used, it seems strange that they should have been adopted as the best means for securing insulation in circuits of such high potential as are employed on the Richmond road.

The trolley itself seems to be a great source of trouble, and difficult to manage properly. As has been shown, it consists of a grooved wheel at the end of a counter balanced pole held by a spring against and making contact with, the under side of the working conductor. In rounding curves it must be carefully watched by the car conductor to prevent it leaving the trolley wire and thus stopping the car, and at night extinguishing the lamps which has proved exceedingly disagreeable to the passengers, while on busy days it has seemed necessary to put a third man on each car at additional expense for the sole purpose of attending to the trolley. Sometimes the trolley pole has broken or the springs holding it against the wire given away, stopping further progress of the car or requiring a man to stand on the car roof holding the trolley pole against the wire until the repair sheds were reached.

One of the most unsatisfactory features about the arrangement of the Richmond road is the ground circuit, not only because of the difficulty of getting a good ground, which has in this case only been accomplished by connecting the track with the whole gas or water works' system of the city, to the detriment of our exchange telephone system, so well described by the telephone superintendent, Mr. McCluer, in his paper before the recent telephone convention, but the fact that it is necessary to have a clean track to work on; otherwise vivid flashes of electricity will

appear to the terror of the horses in the vicinity and damage to the motor, or should it happen that there is a sufficient quantity of dirt on the rail, it will cause a higher resistance than the potential of the current can overcome, and of course stop the car. Should the motor, man get off to push it over the dirt, and fail, as sometimes happens, to switch off the current from the motor, the full current on the line will pass through it just as soon as a good contact is made, and the result is a burnt armature and a disabled car. This seems to have been particularly the case during the recent stormy weather, when I am informed, that the number of available cars for traffic on the road was reduced to about ten. Possibly the saturation of the motor by the rain and the effect of lightning on the trolley wire had also something to do with the case. Owing to the reticence of the employes previously referred to, it has been difficult to ascertain just what damage has been caused by lightning striking the trolley wires and injuring the motors, but that there has been serious trouble from this source, I have no doubt. The very best forms of lightning arresters have not proved sufficient to prevent injury to electric light dynamos where insulated wires are used on the out-door circuits, while the bare wire used for the working conductors on overhead electric traction systems, must always render them more susceptible to trouble from this direction.

After setting forth some of the difficulties which have been shown in the practical operation of the most extensive system of electric traction in the world, it gives me pleasure to direct attention to the remarkable behavior of the Sprague motors under all the conditions to which they had been subjected for the past seven months, which has been indeed remarkable. No load has been too heavy, and no grade too steep for them to ascend. Perhaps the severest test they ever received was on the night of July 4th, in bringing the crowds from the new reservoir park, when the ordinary open cars carried over one hundred passengers, and the closed cars over seventy-five each, so many in fact that the axles of one or two of the cars broke down under the load. All of which must be exceedingly satisfactory to the inventor, and places the Sprague motor at the very head of the many excellent types or forms that have been devised at home and abroad.

The objections referred to apply equally as well to all forms of overhead systems, except where a second wire is used for a return instead of the track and earth, and also where the

trolley pole is discarded for the movable trolley. But the increased number of aerial wires required, as well as the heavier fixtures needed to sustain them, render these systems just as objectionable.

We are very anxious to see the effect of ice, sleet and snow upon the operation of our road, as it has not yet passed through a winter in complete running order. A heavy sleet storm has often prostrated our telegraph lines, and I see no reason why the overhead electric railway wires would be exempt from similar trouble, nor why the covering of the rails by ice and snow will not render it difficult to make sufficient contact to operate the line successfully, not to speak of the loss of current by leakage or escape from the trolley wire.

But I have no doubt that the ingenuity of those who have overcome all the problems encountered in opening up with such success the Richmond Union Passenger Railway, will be sufficient to insure its continued operation in spite of wind and weather, and to no one more than myself, will this be gratifying, since it was through my efforts that attention was first directed some three or more years ago, to the splendid opportunities for electric traction that Richmond presented. Although I am free to confess that my inclinations were towards the application of the storage battery, which obviates all the troubles and defects developed by the overhead systems, and against which no more serious objections seem to be brought than the extra weight caused by the batteries and the greater first cost as compared with the aerial systems, all of which, it appears to me, are more than counterbalanced by the difficulties and annoyance in the systems just described.

The very satisfactory results obtained in the operation of the new electric storage cars on the 4th Avenue Railroad in this city, as well as by Mr. Wharton in Philadelphia, M. Huber in Brussels and elsewhere, prove, as I have always believed, the storage battery to be the only ideally perfect system of electric traction for municipal purposes.

THE CHAIRMAN:—Gentlemen, if it is agreeable to you I will ask the Secretary to read Mr. Robinson's paper, as Mr. Robinson, I believe, is not here. Then, after the reading of the papers, the discussion will be open.

There being no objection, the Secretary read Mr. Robinson's communication.

NOTE ON GEARING FOR ELECTRIC RAILWAY MOTORS.

BY ALMON ROBINSON.

Probably no one will be disposed to deny that in devising a connection for the motor and the car wheels, what Mr. Sprague attempted to do, has been done extremely well. Has he attempted all that is desirable?

Mr. Sprague's investigations have shown that, in street car work, a very large percentage of the whole power used is expended in starting the cars. Now it seems to me, that a motor whose speed has a fixed ratio to that of the car wheels, must work uneconomically when the car is moving slowly, for no amount of skill spent in varying the magnetic circuit can prevent an armature from wasting a current sent through it when it is practically standing still.

Perhaps, however, Mr. Sprague may be able to show that a properly designed motor will work with a high efficiency in doing anything which he puts upon it in railroading?

But, even in that case, there would still remain the extra cost and extra weight of a motor large enough to lift its heaviest load by a dead pull.

To do the hardest part of his work, Mr. Sprague is really using a thing in which he disbelieves—a slow moving motor.

In the storage car problem this matter of weight, and bulk, and cost, becomes the most important element. Here, the present practice is simply, the hauling about of ten men to do by main strength what one man could do by a lever.

The desirability of a variable leverage for the motor has not escaped the attention of experimenters. In Mr. Henry's Kansas City work, an arrangement of toothed gearing and clutches was tried. I have never learned whether this particular feature proved a help or a hindrance; nor whether it is in use on the Henry road said to be running at San Diego, Cal. A prominent

inventor has expended a good deal of ingenuity on the details of a plan making use of reciprocating friction pawls. Mr. Reckenzaun tried and abandoned a leather covered chain, clamped between two cones in such a way that the diameter of the circle of contact could be varied.

Mr. Van Depoele has suggested, and I presume tried a connection having two different speed ratios, in which friction gears were used. For this particular purpose (furnishing a variable speed ratio) I am obliged to confess myself a believer in the possibilities of frictional gearing.

For electric railroad work, it is certainly under a cloud at present. Those who have used it most, like it least. The eminent engineer, who, about a year ago, read a papér before the Institute on "Methods of Gearing," seemed to consider that it had been sent to its last resting place by the experts who tested some of Prof. Fleeming Jenkin's devices.

No one seems to notice that every day, and on every railroad this method of transmission gets the roughest possible testing; that every locomotive pulls its train by frictional adhesion; that a rail and driving wheel are neither more nor less than a frictional rack and pinion. When we try to copy the work of the locomotive under other conditions our troubles begin. But no man who has ever seen a freight engine climb a grade has any right to speak with disrespect of frictional gearing.

The real root of all the difficulties with frictional transmission seems to be that the pressure producing adhesion does not vary with the dimensions of the gearing; so that when we reduce the size and increase the speed of the gearing, the friction at the journal bearings soon becomes enormous. For light work this is partly obviated by using, instead of metal, some more adhesive material, such as paper, rawhide, etc. But none of these surfaces will stand a pull at all comparable with that on the surface of a locomotive driving wheel.

The most promising methods would appear to be those in which the pressure is prevented from acting across the bearings. This idea is carried out to some extent in the well known V grooved gearing; but the unavoidable sliding and grinding of the surfaces makes it impossible to obtain a high duty from it. The idea is more fully carried out in the devices of Sellers, Jenkin, and others. I do not know that anything has been suggested—I certainly cannot suggest anything—which does not leave, for the

purpose under consideration, much to be determined by trial. Knowing well the effect which actual trial is apt to have upon untried devices, I cannot blame an engineer who prefers to let well enough alone, if a fixed speed ratio is all that he cares for. But I cannot help thinking that a useable connection, which left the speed of the motor independent of that of the car, would be a valuable acquisition; and that a probability of obtaining it would amply justify further experiments with methods of gearing.

Lewiston, Me., October 3rd, 1888.

THE SECRETARY:—I might say, in connection with this note of Mr. Robinson's, that he was present at the meeting at which Mr. Reckenzaun read his paper, and he told me personally, that he was much interested in the subject of frictional gearing, and he felt that it had received a "black eye" from Mr. Reckenzaun's paper.

The notices which were sent out announced probable contributions to the discussion by Messrs. Mansfield and Blackwell. I have a letter of regret from Mr. Mansfield of his inability to be present, and I am not certain whether Mr. Blackwell is here this evening. There are no other papers.

DISCUSSION.

THE CHAIRMAN:—Is Mr. Blackwell present to-night? If so, we should be very happy to hear from him. He does not seem to be here.

The interesting paper of Mr. Leonard and the note of Mr. Robinson seem to afford very good starting points for the discussion, and the question is now open for any gentlemen who may wish to speak. I see there are a number of gentlemen more or less intimately connected with electric street railways and electric power present, and we should be glad to hear from any of them.

We should be pleased to hear from Mr. Ries of Baltimore, who, I see, is present with us this evening.

MR. ELIAS E. RIES:—Mr. President and Gentlemen:—It is not often that a paper upon so broad a topic contains so much solid meat, within, comparatively speaking, so limited a space, as the one we are here this evening to discuss. Mr. Sprague deserves to be congratulated upon the ability and thoroughness with which he has presented the subject, and I take pleasure in adding what little I can to the discussion of such of its features as it seems to me require more elucidation.

The paper, generally speaking, may be divided into two parts; one dealing purely with the "Municipal Rapid Transit Problem" as determined by the conditions that obtain in New York city, and the other with regard to the construction and operation of ordinary electric street railways. I shall take up the latter phase of the paper first, and then, if time permits, will have a few words to say on the general subject of rapid transit as applied to the requirements of New York city.

Mr. Sprague in his paper refers to several methods of converting the momentum of a train into useful current, one of these consisting in converting the propelling motor or motors of a train into braking generators when running on a down grade or coming to a stop, and returning the current generated back into the line for the purpose of assisting other motors. This method necessitates raising the counter E. M. F. of the motor until it exceeds the direct E. M. F. of the line, and as this latter is 400 or more volts, it will be apparent that only in a few exceptional cases is the train energy or momentum sufficient to develop in the motor or motors anything above the initial electro-motive force for any appreciable length of time. During all this period the energy of the train is simply being expended in overcoming the direct E. M. F., or in other words, in preventing the entrance of the line current to the motor by developing the 400 or more volts necessary to oppose it, a result that can be as readily obtained without the expenditure of this energy by simply opening the motor circuit. The practical effect of the method referred to will be to partially brake the train, but except in a few extreme cases the line current derives no benefit or assistance therefrom. There is, however, another and more economical method of conserving the surplus energy of a railway train, which avoids the loss of the bulk of this energy, and at the same time permits of the utilization of this energy *upon the train itself* at times when it is most required. This method, as developed by me some time ago, consists in the employment of a secondary battery, so arranged as to be connected with the motor-circuit whenever, as in stopping or descending a grade, the connection between the line and the motor is interrupted, and the latter is in condition to generate a current under the influence of the momentum of the train. The battery cells are connected in parallel or multiple series order during the time when they are in circuit with the generating or braking motor, so as to oppose an electro-

motive force of only a few volts to the charging current, thereby making the movement of the train or car instantly available for charging the battery, this charging process continuing until the speed of the armature has been so reduced by its own braking action upon the train or car, that it is no longer capable of generating the few volts necessary to effect the entrance of its current to the storage battery on the train or car. In this arrangement an automatic potential switch of special construction prevents the closing of the charging circuit until the E. M. F. of the current from the generating motor exceeds that of the battery which occurs almost instantly, and breaks the connection, when the E. M. F. of the charging current falls below that of the battery, the entire arrangement being so simple as to require no attention whatever on the part of the motor-man. The current thus reclaimed on descending grades and stops is, in the Ries system of electric railways, employed to assist in operating the train or car when ascending grades and starting from a position of rest. The battery, or such portion of it as may be set aside for operating the motor or motors, is of course discharged at a higher voltage, and can be utilized for electric lighting and all other train purposes to which it may be applicable. It will thus be seen that a twofold effect is obtained, since the surplus energy of the train, which under existing conditions is ordinarily wasted, is not only made to stop the train without the use of friction brakes, but the energy consumed in stopping the train is, with the exception of a very slight loss in conversion, etc., almost entirely recovered and turned to useful account. Mr. Sprague has stated, in referring to the operation of the New York elevated railway system, that 59 per cent. of the power expended by the locomotives on a round trip is used in starting, 24 per cent. in lifting, and only 17 per cent. in traction. That means that 83 per cent. of the total power expended upon the elevated railway system in this city is consumed on account of stoppages and grades, of which nothing is recovered, but on the other hand, the waste is augmented by the use of further steam to apply the brakes. If only one half, or say 40 per cent. of this wasted energy, can by the method above described be recovered, of which I have not the slightest doubt, the value of electric traction for roads of this character, over that at present used will be apparent, from this standpoint alone.

Another matter of considerable importance is whether one or

two motors are most advisable for street car work. I myself am in favor of employing but a single motor directly geared to both axles, and it is the universal opinion of electricians and engineers that in a case of this kind a single large unit is better than two or more smaller ones, and this is especially true in regard to street car motors. A great deal has been said about the difficulty of making satisfactory connection with both axles from a single driving source, but this can be overcome, and I may say I have devised a method of doing this which avoids most of the difficulties heretofore encountered. It is a question to my mind whether Mr. Sprague's assertion that independently driven axles necessarily give better track adhesion, can be sustained. In fact it seems to me that the reverse is generally the case. There can be no doubt, as Mr. Sprague states, that independently driven axles will slip until they get the best grip, but it is also known that a sliding wheel or pair of wheels will readily continue slipping under the influence of the acquired impetus and the rotative strain exerted upon them by the motor. However, in ordinary street cars the load is constantly shifting from the forward to the rear axle, and vice versa, due to the lurching of the car and unequal distribution of the weight or load. Therefore, supposing a car to be slightly overcrowded at its rear end, the forward wheels must necessarily slip, and the motor driving them will run light for the time being, leaving the rear motor, which was designed to do but half the total work, to do it all, and subjecting it to an enormous electrical and mechanical strain. I have given this subject considerable attention, and have come to the conclusion that for street cars of ordinary construction the axles should *not* be independently driven, but should be directly connected with each other, preferably through the armature shaft of the motor itself, whose weight is equally borne by both axles. In this manner the combined tractive effect of all the wheels may be obtained in unison, which will reduce the tendency to slip, and the load upon, and work done by the motor will be a constant quantity irrespective of the shifting of the load. For pivoted truck or eight wheeled cars the objections to independent driving do not so seriously apply, but the advantages of a direct connection with both axles of a truck are even more apparent for other reasons.

I thoroughly agree with Mr. Sprague on the matter of making each car of an elevated train its own motor, provided the motors of the entire train are controlled from a single point. In all

cases where stops are frequent, this plan possesses numerous advantages, but for trunk line railways having substantial road beds a single large motor, or perhaps a front and rear motor suitably connected but capable of independent operation when separated, will probably always be found preferable to a number of small ones.

One thing that struck me as very peculiar in connection with the Richmond road, was that an electrical engineer of Mr. Sprague's ability and experience should so utterly abandon all measure of precaution for the safety of his passengers and the public at large as would seem to be indicated by his employment of the track rails and ground as one side of the circuit, instead of using a double overhead conductor. This is the more to be wondered at, when it is shown by Mr. Sprague's own description of the elaborate and extensive means employed for connecting the track rails and re-enforcing them by separate wires to insure perfect connection with one another, and with the ground pipes, etc., that aside from its danger, this plan is considerably more expensive than a second overhead wire and double trolleys would be. I can only explain this action on the part of Mr. Sprague, by assuming that he has found the track return necessary to enable him to ascend the steep grades of the Richmond road, by reason of the increased tractive adhesion obtainable, due to the passage of the propelling current from the wheels into the rails. If my memory serves me rightly, it was not very long ago,—in his address before the American Street Railway Association, at their Philadelphia convention last October—that Mr. Sprague stated that on roads having grades of more than six per cent. he proposed to attach a hill horse to the motor car. Whether he intended this as a parting tribute to the usefulness of the patient and long suffering car horse who has so faithfully served the public, I do not know; but at all events he stated that he did not believe it possible for a self propelled car to get up the hill in any other way. This was some time after I had announced the results of some experiments I had made, both with the electric current and electro-magnetism, in which I was able to show and demonstrate that the tractive adhesion of driving wheels could be very largely increased by these means, sufficient in fact, to enable a motor car to ascend a grade much steeper than any yet surmounted.

However, I might state here for the benefit of Mr. Sprague

and others, that this increased tractive adhesion can be obtained without subjecting the public at large to the danger incident to the use of a ground return. Every electrician knows, and perhaps no one better than Mr. Sprague himself, that a ground on any circuit multiplies the danger of leakage, and on an electric railway circuit carrying a pressure of 400 or 500 volts it should never be permitted. In the Ries electric railway system we have a cheap and simple method of increasing the tractive adhesion without employing the track rails as a return, which can be applied to any electric railway operating on the parallel system. This consists simply in passing the current from the conduit or overhead conductors, after it leaves the motor, to the forward car axle, which of course is insulated from the car body, and to connect the rear axle, also preferably insulated, to the negative or return conductor. In this way the current, after passing through the motor, must traverse that portion of the track rails lying between the two pairs of wheels, which latter are thus included in the circuit. The portion of the track rails traversed by the current will not act as a ground but simply as a good conductor inserted in the branch or loop that feeds the motor. This is only one of a number of ways in which an increased tractive adhesion may be obtained, but I prefer in most cases to employ a current that is entirely independent of the motive current and of such quality as to produce a very much greater and at the same time a variable tractive effect. I may say that we are at present engaged in applying this system to an ordinary steam locomotive, on a prominent railroad, and if the results obtained prove to be anywhere near what we have reason to expect from certain experiments made on a smaller scale, I shall hope to be able to show you a very decided increase in its pulling capacity, and to effect a considerable saving in the cost of operating the road.

With reference to the ideal method of braking referred to in the paper under discussion, I might state that a modification of our electro-magnetic traction apparatus has been applied by us for this purpose. In this we magnetize the car wheels as in our traction apparatus, but in addition provide an electro-magnetic braking arrangement, the whole being so arranged that when the brake circuit is closed, not only are the brakes applied to the tread of the wheels, but the co-efficient of friction between the wheels and the track rails is greatly and simultaneously increased, thereby enabling us to apply a greater brake-shoe pressure than

now possible, and yet prevent the wheels from skidding upon the rails. This method of braking is effective in almost any weather and is applicable to street cars or to railroad trains. In cases where braking is effected by utilizing the motor or motors as braking generators, as before explained, this system is still available and only the traction circuit needs to be established between the two axles of each truck to render it effective. This in my opinion constitutes the ideal method of braking, and before very long I hope to be able to show you such a system in practical operation.

I have already occupied more time than was my intention, and though there are several other matters that I should like to have called attention to, I believe I have said all that is necessary, and will leave something for others to say while I listen. I appreciate and thank you all for the compliment bestowed in calling upon me, and for your kind and respectful attention.

MR. J. M. PENDLETON:—I rise to make an inquiry. I have heard several eulogies on the Sprague motor that is used in Richmond, and I would like to inquire whether the motor in use upon the cars in Richmond is anything but a plain, series-wound Siemens armature. If such is the case, it seems to be a very old form of motor—one that certainly possesses nothing to give it a title except the maker's name. I think we ought to give to those who have invented certain forms, the credit of inventing those forms. A short time ago I looked over a work lately published by Mr. Silvanus P. Thompson—a very excellent text-book, and one that must form a very valuable addition to any electrical library. In that work, replete with everything that an electrician would value, I found on one of the pages a very strong endorsement of the Immisch motor—a motor that is well known in England, and one which it has been attempted to introduce in this country. To my surprise I found my own name and that of another inventor mentioned on that page as having invented a motor of a form discarded by Mr. Immisch. Now, it struck me at the time that it was a misfortune that so valuable a book should contain anything to mar its high merit. A little motor intended for a very small use—a sixteenth of a horse power—was not a fit subject for such a remark; and it naturally occured to me to ask what there is in Mr. Immisch's motor peculiar to Mr. Immisch. It is certainly nothing but a Siemens armature in a two-pole field, and there was nothing indicative of the inventor

about it, and the name of the motor certainly belonged only to the manufacturer. Now, in these motors, we know that Mr. Sprague has spent a great deal of time and given a good deal of study to certain lines of regulation in motors, but they are certainly not adapted to car purposes, and if a plain series motor is put upon a car why should we call it one thing or another? Therefore I think the inquiry is pertinent. Is there anything in the motor except that it is a series-wound motor such as we have been familiar with a great many years, even before we knew the names of a great many manufacturers who certainly cannot claim the invention of a motor of that class.

MR. C. O. MAILLOUX:—It was at first my intention not to say anything in the discussion this evening, but I think it is my duty to speak disinterestedly of the matter brought forward by Mr. Pendleton. While it is true that there are very few types of motors existing, and that in fact the question of selecting a type, in the mind of an electrical engineer who is about to design a motor comes down to but two forms strictly speaking, yet it does not appear to me to follow necessarily, that we should be compelled to give to the motor designed merely the name of that peculiar form. We have only to look into other fields of engineering—and I know no better example than that of the steam engine—to see how the names go. If we were to give absolutely to Cæsar what is his, the engines that we use to-day would be known by the names of people who lived before we were born. As a matter of fact, while James Watt may have done a great deal for the steam engine, yet it does not follow that he is entitled to the full credit of the steam engine, because if we were to place the engine designed by James Watt in contrast with the engine designed later by Corliss, we would find quite a difference, and if you would come down still further and compare with the triple expansion compound engines now being made you would find a still more marked difference. Yet, strictly speaking, they are all of the same type—a reciprocating piston taking steam at both ends, and the variations merely come in the form of valve motion and various other details. Now, the criticism made by Mr. Pendleton would imply that in designing a motor you have only to look at a book and find a picture that suits you the best, and then if you decide that it is to be a series motor or shunt motor, you simply go to work and have it made. Now, to us who have been through the mill—who "have been

there," as the saying is, we know that the process is far from being as easy as that. We know that there are very intricate calculations to be gone through, and calculations that must be gone through under very adverse and trying situations, inasmuch as, so far from the art being entirely known, we are in fact only on the dawn of knowledge. In other words, the data that we have to work from are very incomplete, and where facts, figures and principles end we must go often into the domain of the hypothetical to help ourselves out. Now, I think that so far from disparaging the efforts of people in designing, we should on the other hand, certainly give them credit for what they have done, because we ought to realize the amount of study, hard work, experimenting, and oftentimes expense which has been necessary to enable them to arrive at those results. I speak feelingly on that subject, gentlemen, because as I have just said, I have been there myself lots of times, and I know what it is to design a dynamo-electrical machine or an electric motor, and I also know how it is to strive to accomplish results under difficult circumstances. So I think that just as we give credit to designers of steam engines and designers of other things, who simply re-arrange details and use their best skill as engineers, for the work which they have done, so we should give credit to electrical engineers for the work that they are doing; and I claim that if Mr. Sprague or anybody else is able as an electrical engineer to combine material and to mould it so that it shall accomplish results that nobody else has accomplished, that he is perfectly and fully entitled to have the motor known by his own name, just as much as a steam engine is known by the maker's name. (Applause.)

MR. PENDLETON:—I think, Mr. Chairman, in the matter of the pleadings of my friend Mr. Mailloux, that he is always very ingenious, and very kind in matters pertaining to inventions, although he did not directly reply to my question. What I meant was that where a man has really become an inventor and a student in certain styles of regulation and has combined with this, other patents and other matters, he is entitled fully to the benefit of his work and to have it known as his work and his style of apparatus; but where he departs from that to another type, why should that name be continued when it is nothing of his work, and belongs to somebody else. That is what I spoke of. I did not intend to throw a bombshell into the controversy.

It was a mere inquiry. I heard the matter lauded and although I know the work of Mr. Sprague, his very intelligent and you may say audacious attempt to overcome the natural difficulties of a city having the grades of Richmond, for which he is entitled to the highest credit; yet at the same time I thought that it might be well to distinguish what belonged to one and what to another. There is no regulation in the motor of the peculiar type that we know of belonging to Mr. Sprague and which is particularly his property. I saw a short time ago in the *Electrical Review* of London, a remark that in America the very slightest difference seemed to create a system. It seemed to me a very appropriate remark and hence my simple inquiry whether that was a simple series-wound motor of the ordinary type that was used.

THE CHAIRMAN:—I do not think there is any danger of Mr. Sprague's reputation for his distinguished service in the matter of street railways suffering any harm in a meeting of the Institute of Electrical Engineers; but I think we might better return to the discussion of the subject of the evening—Mr. Sprague's paper, and the criticisms that have been presented upon it here to-night.

I hope other gentlemen will take part now in discussing the papers. Some interesting points were noted by Mr. Leonard particularly in regard to what he considered the deficiencies of the overhead system and the relative merits of the storage battery, and there are gentlemen here, I think, quite well acquainted with those topics or any other points brought forward in the original paper or the papers read this evening.

DR. WHEELER:—I see that Mr. Sprague is present. Perhaps he can add something to what he said last spring on the subject, and perhaps reply to some of Mr. Leonard's remarks.

THE CHAIRMAN.—My defective eyesight will have to be my excuse for not seeing Mr. Sprague. I hope he will speak to us at this time.

MR. FRANK J. SPRAGUE:—I am rather glad that some argument has come up in the discussion of the paper. I think possibly I am in a position to correct some of the impressions which have been received so as to remove doubts about certain points. I do not care to enter here into a discussion as to whether any work that I do shall go under my name or in some other man's. So far as the difference between the Sprague motor in Richmond and the Siemens machine is concerned, either Mr. Pendleton does

not know what the Sprague motor in Richmond is, or what the Siemens motor is. We use in Richmond a double commutator machine which is unknown to-day to any one except those whom I have taught. Its plan of winding has never been published or described. It is, as I say, unknown except by the employees of my company, and if there is any question as to the similarity of that winding to some other, I have not the slightest objection to giving the necessary diagram of connections. It is a series machine, but a series machine which has some peculiar characteristics. It is wound with three sets of coils, and the peculiarity very largely consists in the method of connecting, and certain switches, by which the coils in these machines are commutated and reversed, their field magnetization and their current varied at will, through progressive changes, by means of which, when desirable, we are enabled under various loads to maintain an almost absolutely constant field, while the current may vary 300 per cent. That has never been done with a motor before; that is, to so regulate the field that, with a variation of 300 per cent., a perfectly constant field will be maintained. This field connection is somewhat peculiar, so much so that it would be useless for me to attempt to describe it now, although I shall take occasion to publish a description of it in the near future. There are, however, some characteristics of motors other than the mere winding of the armatures or fields, or their regulation, which are essential for street car purposes. It is, as Mr. Mailloux says, a question partly of proportioning, partly of calculation, a putting together of those things which you have at hand to meet those conditions under which you have got to work. Two years ago, I think I may fairly say, such a problem as equipping the Richmond road, with its abnormal conditions, with the circumstances of manufacture which we had to meet, and in the time that was given to us in the then undeveloped state of this art, would have been looked upon as somewhat preposterous. I am frank to confess, that, had I known what I had to go through, I would, perhaps, have had neither the necessary courage, time or patience, or have cared to have risked the money which I did. I have spent in Richmond $150,000 and I have learned something. While I do not care to state all that I learned, I have taken advantage of it in our future work. A great many of the principles of regulation that have been associated with my name are not characteristic of the Richmond machines. They are designed for other purposes. Now,

referring to Mr. Leonard's paper, a great many of the deficiencies he speaks of exist in Richmond, and unless the machines were of superhuman design, they must exist there. A year ago those machines were put in in a great hurry. The maximum normal capacity that they ought to run at is about seven and a half horse-power. Very frequently they have been called upon to develop ten or eleven horse-power, an increase of about 50 per cent. In the nine months during which this road has been in actual operation, and it has run nearly half a million of miles and carried millions of passengers, not one working car has ever been inside of a closed shed. They have been housed in the street. The photograph which you have in the report of the paper read by me some months ago gives you some idea of where the cars have been kept. Of course, you are aware that when a machine is running it is exposed to more or less wear. It needs something of care and attention. A locomotive that makes two or three hundred miles, is sent in to a round-house, thoroughly cleaned and taken care of. It is a very good locomotive that will run with safety, and it is very poor management that will permit it to run more than three or four hundred miles without looking it over. The Richmond machines have run sometimes as high as 6,000 or 8,000 miles without being sent inside a covered shed. They have run without covers of any kind or character. They have run with six inches of water in the street and brake-beams running in the water, which was splashing on the motors. They have run until you could not tell what the machine was; until the accumulation of mud and oil and filth was of such a character that no other piece of machinery in the world would ever have run. I am not responsible, unfortunately, for the management of the Richmond railway. If I were, we would not have the possibility of a number of cars lying in the car shed, so-called, unfit for duty, after having been left in the streets during ten days of rain. The report from one of my own inspectors less than one week ago was that there was no more trouble in running a 40-car road by electricity than on one operating three or four cars. He is a level-headed, practical, cautious man, not given to strong statements and very conservative in what he says or does. He says that out of 30 cars equipped for duty, there is no difficulty whatever in maintaining 29 on the road, if only that legitimate, ordinary, reasonable care is given to the machines which ought to be given to them; and that is the opinion of others who know the exact circumstances of

the Richmond management, and the character of the attendance which the machines have had. There is no electric car in the world which has ever made anything like these records—from 80 to 110 miles a day on grades as high as 10 per cent., under loads 50 per cent. above the normal capacity of the machines, in the hands of the men oftentimes appointed for political purposes and not for intelligence, on duty twenty hours a day, and making 6,000 or 8,000 miles without going inside a shed to be cleaned off. I have been called a crank, and some time ago when I made the statement, as I did in the paper that was read here, that we would get to that position in electric motors in which it would be almost an impossibility in ordinary use to break them down, and that I proposed to wash machines down occasionally, to get them clean, the remark was made, "Well, that fellow must be a damned fool." Well, I quietly pocketed that remark, and within the next thirty days or so we will have the machine out, and we will put one of those armatures that people have laughed about inside a barrel of water for twenty-four hours, and we will take it out and we will run it. There is no piece of electric machinery in existence to-day that will stand it. One of the difficulties which will occur on any road where cars are not properly and decently housed some part of the twenty-four hours is this: Cars that are running, of course, warm up, the pores open, they are ready for the absorption of any moisture. If it comes on a cold, damp, murky night, and these cars are left utterly unprotected, they will absorb more or less moisture. In dealing with the potential we are using there of 400 to 450 volts on the line, you have a possibility of a short circuit in the coils. Some of the difficulties Mr. Leonard mentions I think he might have recognized as of a purely mechanical nature, or difficulties due very largely to lack of ordinary care. The breaking of a trolley wire, sometimes caused by a trolley catching in it, can be, of course, almost entirely obviated by one or two precautions; one of these is dispensing with solder in the erection of a line. In putting up the Richmond line we used hard drawn copper. Hard drawn copper as it comes out of the mill has a remarkable tenacity, but when it has been handled, and when under the heat of a soldering iron it has been warmed up, you reduce it practically to the strength of soft drawn copper; so that you will have at the point where solder has been applied a weak spot which entirely nullifies all your other precautions. In our future work, this trouble will be entirely removed, because we

will not use solder from one end of the line to the other. The use of silicon-bronze or aluminum-bronze drawn for high conductivity and great tenacity, will likewise render less possible any accident due to the breaking of the wire. This wire can be drawn of from 100,000 to 150,000 pounds tensile strength to the square inch; and being put up without solder, I can see little possibility of that wire ever coming down.

So far as the use of poles is concerned, if you use a green pole, as the poles in Richmond were, it will bend; if improperly set in a clay soil it will get out of position. If it is properly seasoned and set in concrete there is no reason why it should give trouble. One of the most important roads that we have—we have some 26 or 27 now—is the West End road of Boston. Rights for an overhead system there having been granted within a few days, we are putting up a line that costs four times as much as the Richmond line did per mile. I believe I said in my recent paper that the objection to overhead wires was entirely reasonable, because people did not put money enough into them. Having put all the money which I did in the Richmond road, I do not propose to put in any more there. On a new road, where I can make my own conditions before the contract is signed, I am willing to put in just as expensive a road as is desired. Instead of putting in wooden poles in Boston, we are putting in iron poles tested up to 1,400 pounds. Instead of setting them in clay, we set them in concrete. Those poles will not come down. So far as the span wires are concerned there is no danger of their breaking.

As to the use of a single overhead line that I know is a much discussed question. But I find the practice of most people is a single overhead line. There has been a good deal of kicking on the part of telephone companies. It has chiefly disappeared down in Richmond. The trouble is that the telephone companies had the earth and they wanted to keep it.. (Laughter). I can see no particular reason why a telephone company should not be required to exercise the same degree of care in putting up their lines that they would if the electric railroad were already in existence The telephone man runs out his circuit as far as he can and charges as much as he can, and then, because some poor railroad company wants to put in some cheap and effective system of operating its cars, I do not think that it is quite just on the part of the telephone companies that they should raise their

hands in such holy horror over the use of the earth circuits. Mr. McCleur, of Richmond, who was mentioned, had ingenuity enough to get out of his troubles. He took the trouble to run over his main telephone circuits, where they came near our wires, a single return wire, and he makes his telephone connections to that. His troubles have disappeared. I suppose it might have cost his company a few hundred dollars. If he objected to paying that, I suppose we could have paid it for him; but he has, as I say, overcome his troubles by the most trivial possible expense. If that is the only objection that telephone companies have got, it is not a legitimate objection. So far as the burning out of their exchange is concerned, I will have to correct Mr. Leonard in that. At the time one of their decayed poles fell down and landed three or four hundred wires on top of our lines, the dynamos were not running at all. This is the only pole breakage I know of. We have burned out some of their instruments, but that is simply because we took a reasonable amount of precaution, and they did not. They got their wires across ours, and they got the worst of it. The great trouble with telegraph and telephone business is this—the thousands of miles of dead wires hanging down in the streets and over the house tops. A man who has a telephone does not take the trouble to take down his telephone wire after he has discontinued the service. There is no æsthetic sentiment in a telephone company. They are perfectly willing to say: "Here, you electric light people and you electric railway people are causing a great deal of trouble to our customers." If they would all join hands in an equitable arrangement, as some of them have, they would have little cause to complain.

A criticism has been made about the use of two machines on a car. I have spent half an hour trying to get the length of this room with one motor on a 6 per cent. grade, under a condition which happened to give a slimy surface on the rail, and I have seen under the same conditions, on a 10 per cent. grade, with a worse track, two motors handle the heaviest loads. It is not merely because the wheels can get a better grip—you have got your total weight available for traction. The forward wheels can also in case of an emergency travel faster than the rear wheels. That has been done—even on a level, and has the advantage of breaking up whatever obstructions there are on the track and leaving the track perfectly clear: if you put between your wheels

a broom or brush you have excellent traction. It could not be done by gearing both wheels to the same motor, simply because you could not get that independence of grip that is necessary. Running both pairs of axles requires certain devices, the use of which, in view of existing street car practice in the matter of constructing running gear, I do not think advisable. There are some 40,000 or 50,000 cars in the United States, and there are one or two settled principles in them; one is, perfectly independent action of the axles. No four wheels on a car are of the same diameter; they are never cast absolutely alike; they do not run necessarily on the same tread. Any difference in the level of the streets will send the weight of a car down on one side, in fact, it seems to me, in the face of all I have seen, almost trivial to make any objection to the independent driving of two axles. I admit it is cheaper to build one machine to put on a car, but you can build two smaller machines of the same capacity. Space in a street car is a matter of considerable importance. You want to get large power on a car to handle heavy loads, but you have got to have it in comparatively small space.

As to keeping a trolley on a wire, I am quite willing to enter into a contract to put a trolley on a car which never can come off the wire, and, in fact, some of our cars are now running with one man, and have to run with one man, simply because the railroad people won't pay an additional conductor.

The methods of getting rid of troubles have been, of course, subjects of a great deal of study. It was not possible a couple of years ago to look forward and face all the conditions that arise in practice. We electricians did not know enough about street car practice, and street car men did not know enough about electric railways, so we had to join hands with the street car men, and we had to put the cars and motors into the hands of ignorant men and meet those difficulties in order to know how to get over them. I think I may safely say that the road we put in, sixty days from now will bear about as little resemblance in details to the Richmond road as it is possible for any two roads to bear to each other, simply because of great improvements, not only in the motors, but in the gearing, switches, trolley work and all overhead superstructure.

A two-wire system requires from two to four times the weight overhead. Where we put a main conductor alongside of the street and reduce the trolley wire to a single one a fifth of an inch

in diameter, that enables us to keep our structure in position a great deal better. So far as safety is concerned the fact that a horse was killed in Richmond in the early days of running is no criterion of it. Two wires are more liable to come down than one; but you won't get killed with 400 or 500 volts. I have several times taken that potential myself. We don't know whether the horse that was killed in Richmond broke his neck or was killed by electricity. He was boiled in order to get his skeleton; he did have a broken neck; it is not known whether that killed him. We had a mule there. (Laughter.) A man threw a lump of ice down on to our wires. The first mule—two of them were being driven by a darkey, ran his head into the wire and kicked and finally fell over and lay on the wire. About half an hour after that they telephoned up to the general manager's office, and said, "We have got a mule pretty well used up by a current; we want damages." He said, "All right." About 48 hours afterward they sent up word that they did not think they wanted any damages; that mule seemed to be a great deal livelier than before. (Laughter.) In the case of the horse, that was gross carelessness on the part of everybody concerned—the conductor who broke the wire, the dog who investigated it, and the boy who rode the horse, but the only one injured was the horse.

The statement that the Richmond Company has never been able to run more than thirty cars out of forty is an error. The Richmond road never expected to run more than thirty cars out of forty. Its plant was built for thirty cars. A forty car motor equipment had nothing to do with their line work, or their central station work. It is perfectly possible as a matter of fact, to run the entire forty cars.

As far as the use of the storage battery is concerned, I am just as anxious as anybody else that the storage battery should be a success. But it will never get on a car in Richmond when they have got to put 4,000 pounds weight on that car. They never will take 20,000 pounds weight up a ten per cent. grade with a storage battery until it is in a good deal higher state of efficiency than it is to-day. We have, although not prominently connected with storage battery work, been experimenting for a long time. We keep a car on tap. We have had built hundreds of plates in the past year, trying to devise some means of overcoming some difficulties that exist in storage batteries now. We hope to have a normal capacity of discharge in, say a 35-pound cell of not less

than 75 or 80 ampères, and ability to stand 150. The resistance ought to be about one third or one-fourth of the present storage battery. The plates will be practically indestructible; and, finally, it won't be a Faure cell. That is the sort of thing I am looking for. I do not know whether we will get it. The results, so far, have been very encouraging, but we never will attempt to climb a ten per cent. grade with it, and we never will put it on the market until we know it is satisfactory. We will do our own experimental work. We expect to get the battery down so that not more than 1,800 pounds is necessary to handle the car under ordinary conditions. That will be something of an advance. The credit will not be mine, except that I shall pay the bills. Two years ago it was not possible to design a street car motor for entirely perfect work, I do not think enough was known about street car work. Certainly we are in a position to-day to design a great deal better machines than we did then. I shall have the pleasure of showing and explaining to this association in the near future our two latest machines—one about 7 1-2 horse-power, the other about 15—and their construction, I think, will appeal to street car people at least. I think by the time the Boston road is running, which will be in about five or six weeks, if Providence is not against us in the matter of the weather, we shall be able to show such improvement to the overhead line, as to its efficiency, economy and appearance, the character of the motors and the work which they will do, as will be a subject for mutual congratulation.

Mr. Ries:—I should say in regard to the advantage of using one or two motors for propelling cars, that in ordinary street cars there is apt to be a lurching motion and weight is shifted from the front axle to the rear and *vice versa*, and when each axle is driven independently, if the rear platform, for instance, is more heavily weighted the front axle revolves lightly.

Therefore, the work is on a motor that is only half large enough to do it. So far as the slipping of wheels on the rails is concerned, necessitating cleaning the track in winter—that can be accomplished by placing brushes in front of the forward pair of wheels. The principal objection to the use of two motors consists in the fact that it complicates the machinery. On a road, operating say, 40 cars, it requires 80 motors where 40 would do the work. It is not at all necessary in the use of a single motor to interfere in any way with the present existing construction of

the running gear of the cars. It is just as easy to apply a motor to the present cars without making any change whatever and gear that motor direct to the two axles as to give each axle an independent motor. In fact I have developed such a system which avoids the difficulty of removing or changing any portion of the car.

MR. L. F. LYNE:—I would like to ask Mr. Sprague if he really meant that a locomotive only runs 150 miles before it needs repairs. I think he meant 1,000. There are reporters here, of course, and if they get that wrong it will not sound well. I unstood Mr. Sprague to say 150 to 200 miles.

MR. SPRAGUE:—I might as well correct that impression at once, if you will permit me. I said it was not practicable in locomotive work to run over 200 to 400 miles without the locomotive going under shelter and being properly oiled and cleaned; I did not mean going into the repair shop. What I say about the Richmond machines is this: They are not put inside of four walls; they are simply left in the streets. You cannot leave a locomotive or any other machine in the street for eight months under all conditions of the weather and have a machine that will not be apt to sometimes give you trouble.

I was quoted a little while ago as making a remark about hill horses. I was asked by a man who was interested in storage batteries—I believe he lived in New Jersey—if I would recommend in the equipment of a road which ordinari y did not have more than two or three per cent. grade, but which did have in some particular places a heavy grade of eight or nine per cent., the use of motors which would climb a nine per cent. grade? I said that as a matter of commercial investment I would say no. I said: "You will find it cheaper if, when you get to that eight or nine per cent. grade, you take the trouble to put on a horse." That, certainly, was the intention of my remark.

So far as Richmond is concerned, I did not expect in the first place, that we were going to have a ten per cent. grade there. Our specifications were for eight per cent. We have in some places the equivalent of a thirteen per cent. grade. We develop a remarkable traction, a traction which I never anticipated would be gotten out of a car; but no matter how we magnetized our wheels there, unless we drove both axles we never would get up these grades at all times.

Mr. LYNE:—There are one or two points in the discussion

which I would like to refer to. The devices, so far as I have been able to discover, for transmitting the power from the motor to the shaft of the car or axle of the car, have been, in many cases obsolete devices. For instance, the grooved friction wheel has been used on the "Ben Franklin" that was tried on the 9th Avenue road. That device was abandoned by engineers years ago, for the reason that if a sufficient pressure was not brought to bear on these wheels to bring the friction up to the maximum point at once, the surfaces would slip on one another, and produce a flat place. When the Fontaine locomotive came out we were led to believe that the whole railroad system of the country would be revolutionized in a few months by it. A certain few predicted its utter failure, and it failed, principally in consequence of the tires getting flat places on them. As soon as they did get a flat place they began pounding themselves to pieces, and the result was a dismantling of the whole affair. We know that the same occurs in locomotives in climbing grades. They slip, get flat places, and then the tires have to be turned off.

I am glad Mr. Sprague is here to-night and that he has so fully explained the difficulties which have been shown to exist in an overhead line. I fully agree with him that an overhead line must be put up as if it was never coming down, or else it had better not be put up. It is an old principle in railroading that each train should have its own independent motor, whereas, if you have a cable or a wire upon which a number of trains depend for propelling power, when that line fails or any detail fails, you stop your whole road. Now, we have either got to have the overhead line a permanent structure like a bridge or a railroad structure, or else you have got to resort to some means like the storage battery to give each train its own independent power. Then, if it fails, you can throw it one side and let the other trains move on.

I want to say just a word in reference to the storage battery. While I do not believe fully in the storage battery as it is constructed at the present time. I do know that it has been misrepresented in a great many instances. I have been told that it does not give as great an efficiency as is represented. Now, we have just tested some storage batteries, and we have got 80 to 85 per cent. of the charge back, and the failure of some of the batteries—we put in two series in which the plates failed at the end of about three and a half months—was due to fault in the material. We put two other series right in the same place with improvements

that I had suggested from the experience we had with the first batteries, which consisted in placing the plates five-sixteenth instead of one eighth of an inch apart. Then the scales, when they formed, went directly to the bottom instead of lodging across the spaces between the plates, and short-circuiting them. It is this battery that we tested the other day and got 86 per cent. We have had it in use four months with no trouble or short-circuiting whatever. But with the others, with plates about one-eighth of an inch apart, the scales were formed the full size of the little square, and they would tip over and lodge across the two plates. We have to keep at work at them all the time picking out the scales. There is one other improvement which has been suggested and which I think will be adopted. The scales fall to the bottom, and lodge across the wooden bridge or support upon which the plate rests. That can be overcome by simply making one series of plates with a leg at each end standing on the bottom of the cell and the other series of plates resting on a hard rubber support placed on top of the plates that rest on the bottom of the cell. That leaves the space entirely clear for the scales to fall to the bottom. I have great faith in the storage battery, and I believe that a storage battery will be made eventually which will give a good efficiency and be much lighter than the ones now made.

MR. SPRAGUE:—The question of depreciation of line is a question of construction very largely. It is certainly not a question of wear. A consideration of the actual time in which a wire is in contact will show this. With cars that are making two minute headway and running seven miles an hour, with a round trolley wheel, making contact on a round wire, we have almost a line contact, but call it an eighth of an inch contact. Any portion of the wire is in actual contact with the wheel less than one-two-hundred-thousandth part of the time; in other words, in continuous current contact, not over one hour in twenty-six years. Consequently the current ought not rapidly to wear the wire out, and it does not. In fact the period in which any particular part of the wire is in contact is not over one-two-thousandth part of a second when the car is moving seven miles per hour.

The question of insulation, leakage and lightning came up a little while ago. It is a remarkable fact that lightning does not necessarily always follow the single overhead wire. We have had in Richmond quite a number of cases of the line being struck by lightning. Our ground circuit is made by three paths; two

through the boilers and water connections, and a third through a covered wire running about 1,000 feet on poles out, and direct down, to the track. We have had lightning come over that wire several times, and the statement of the engineers is that it is about an even thing whether it comes in on that line or the other one. It terminates in a well, and as a matter of scientific interest the engineers sometimes watch it as it goes into this well. So far as the leakage is concerned on that line it can easily be reduced to an average of one-tenth or one one-hundredth part of one per cent. It has never been sufficient to cause the slightest interference with the operation of the wire except in the case of the short circuit. If existing, it can very easily be perceived by taking the reading of the ampère meter. The leakage is nothing so far as loss of power is concerned.

Mr. DAVID E. LAIN:—If anything that I may say from what little experience I have had with electric locomotives will add anything to the success of this meeting, I shall be very glad to give it.

About the only point that I care to consider at the present time is the means of coupling the armature of the motor to the driving wheels. In Mr. Sprague's excellent paper he classes the method of direct coupling with those others, coupling by means of chain gear, friction gear, etc., in a way which, I think, is rather hard on the direct coupling. I have had some experience with some of these methods, and it seems to me, as far as I have observed that the plan of direct coupling offers certain advantages which no other method has. The easy motion and perfect noiselessness of the working of this coupling certainly places it ahead of any other means, and its mechanical simplicity is greater than any other, all the details being reduced to a minimum. The objection usually urged is that on account of the slow speed at which the armature must necessarily revolve, running no faster than the drivers, a larger machine is necessary than where the armature may revolve several times as fast as the drivers. This may be an objection and may not. In street railway work, where certainly not more than ten horse power is needed for each car, where the whole equipment should not weigh more than say 5,000 pounds when the car is loaded, the weight of the motor enters as such a small part of the whole weight even with a direct coupled motor, that it is not of such great importance after all. If the drivers be reduced in diameter to say 18 inches or thereabouts, a motor can be built that

is not necessarily more than 25 per cent. greater in weight than one using gear of a ratio of 1 to 12. The smallness of this difference is due, in part, to the greater efficiency of direct coupling as compared to gear. Of course transmission by means of gear is not possible where speed is reduced or changed from say one to twelve, or one to ten, without some considerable loss of power. All this is saved in the direct connection where the loss by transmission should not be more than a very few per cent. Yet we must pardon Mr. Sprague for claiming that his particular system is better than any other, for we are all willing to concede this is but another proof that he possesses the necessary qualities which go to make up a successful inventor, and that Mr. Sprague has also a greater knowledge concerning his system than any other. Yet I think before the close of this year, at least before the close of next year, results will be obtained with direct coupling that will show that a direct coupled motor is quite efficient even for small work like street car service; and if the mechanical efficiency and reliability of this method be also considered, I believe it willl be found to far supass any other means yet employed.

Mr. Leonard:—With reference to the statement in my paper regarding the burning out of the exchange, that report was based on information I received from the telephone manager's office yesterday afternoon.

In regard to the difficulty and trouble experienced by the telephone exchange people, on account of the ground circuit of the electric railway, it has been largely, if not altogether remedied, by the erection of a metallic circuit, or what amounts to the same thing, a large copper wire to which the telephone wires are grounded instead of going to a gas pipe as they ordinarily do. The difficulty has been obviated in that way, but there are quite a number of private telephone lines put up by various people, including our railway company who cannot afford to go to the expense of putting up metallic circuits and the result has been that we have been obliged to discard our private telephone line and pay tribute to the telephone company and their metallic circuit system.

With reference to the mechanical difficulties which Mr. Sprague alludes to and which of course have been improved upon since the road was first erected, it is true that those mechanical difficulties can be considered as such by observation; but the elec-

tric road at Richmond was put forward as being a sample, I may say, of what has been accomplished, and of course we could only take what was actually being done and criticise it accordingly. This I endeavored to do in the few remarks I made. That the work is susceptible of improvement is of course at once apparent to almost every one, and that Mr. Sprague has in other cities succeeded in improving on the overhead system is nothing more than what would be expected from the ingenuity and skill with which he has overcome all the difficulties that were encountered in the Richmond enterprise.

THE CHAIRMAN:—We should be pleased to hear from Mr. Rae on this subject.

MR. THOMAS WHITESIDE RAE:—Mr. Chairman, there is nothing that I have to say in addition to the remarks that have been given to-night, but I would like to record my hearty concurrence with Mr. Sprague's dictum respecting overhead lines. It is simply as with most engineering questions, a financial rather than a technical one. One may have a good, durable, sightly overhead line by simply paying sufficient money for it. As at present constructed they do develop obstacles of various kinds and certainly are not as symmetrical as they might be, and do lack the perfection that might be given by the expenditure of more money. It is quite possible, I think, to make use of an underground conduit at perhaps no greater expense, (certainly no greater when one considers the cost of maintenance of a properly built conduit) than a properly built overhead system would entail, and the difficulties which Mr. Leonard referred to I think cannot fail to be recognized by everybody, but that they are inherent to the system does not necessarily follow, as Mr. Sprague has pointed out very clearly.

MR. SPRAGUE:—I think we will know much more about it when we have gone through a Northern winter which we shall do very soon. We have cleaning cars and we shall put ample power behind them and can run much faster than with horses because we have the power behind us rather than ahead of us.

DR. WHEELER:—Mr. Sprague in speaking of the liability of the wire to wear on account of the current, mentioned the fact that it could not possibly wear because it was only in contact at one point a very small part of the time. But I should think that there would be considerable wear due to the constant sparking that would occur when the roller hops a little bit off the wire.

MR. SPRAGUE:—It is not that to which I referred. It is not the same as a sliding contact on the wire. Your wheel is turning all the while and there is no difference of potential between the part you leave and the part you are going on. You have a good contact where the trolley is held up by a good spring; you may inspect that wire by a microscope and detect very little signs of wear at all. There would be a very slight frictional wear, and it is probable there is a certain percentage of slip of these trolley wheels on the wire. I have, after eight months wear on the very heaviest portion of the line, very carefully inspected the wire, which was chemically cleaned, and I was agreeably surprised to see the small evidence of depreciation. If there is no sparking then the wear is entirely due to friction. The fact is the wear is remarkably light.

THE CHAIRMAN:—We should be very glad to hear from some member of the Society which has been our host here so long and allowed us to use its rooms. I believe Mr. Emery is present and might like to say a few words to us on this subject.

MR. CHARLES E. EMERY:—Gentlemen this is a complete surprise. I came here to learn, because I know nothing of the subject; but I certainly am very much edified and I congratulate the gentlemen not only on the advance in electrical science, but on the advance they have made in organizing a society at which you can all join in the discussion of subjects which are so interesting to you and to us all, and I trust that you will grow to be one of the strongest and best societies in the country. Thanking you for at least the attention of calling on us I will ask to be excused. (Applause).

THE CHAIRMAN:—Have any other gentlemen remarks to make?

MR. SPRAGUE:—I would like to make one remark in regard to lightning. We had the line struck by lightning several times, and we have had motors on the cars burnt out, but I believe I may safely say now that we have got lightning pretty well harnessed. I believe now there is no difficulty whatsoever in absolutely and perfectly guarding a car or a central station, so that lightning simply cannot get to the machine. We had three darkies sitting on the back dash-board of a car; one of them was sitting on the switch. The lightning came in, and grounded through the switch. Those three darkies jumped off the cars at a very lively pace, but there was no danger. We have had the lightning come in and ground through the switch at the time the motor men were run-

ning the car. They paid not the slightest attention to it. They simply heard the click—that was the end of it. It will now be perfectly guarded against. It cannot get into our machines, and it cannot get into our stations; at least if it does it is only one time in 10,000, and then it goes to the earth harmlessly.

THE SECRETARY:—The Chairman of the Committee on Papers and Meetings has an announcement to make regarding the next meeting.

MR. T. C. MARTIN:—The next meeting will be held on November 13th. The subjects are as follows: Prof. W. E. Geyer of the Stevens Institute will read a paper on "A New Meter for Direct and Alternating Currents." We have with us this evening a gentleman whose acquaintance I think you will all be glad to make. He is one of the leading electricians and mathematicians of France; he is also well known as one of the leading contributors to the principal electrical paper in France "*La Lumiere Electrique*." I am very glad to announce that on same evening that gentleman will favor us with two papers, both of which will be accompanied by experiment and demonstrations; one will be on the Carpentier electrical method of recording and reproducing music; the other will be on the Abdank magnetic coil.

MR. MAILLOUX:—I think it might not be out of order to suggest that Mr. Abdank give us some views on the subject we are discussing now.

THE CHIRMAN:—I am sure we should be most pleased to hear Mr. Abdank.

MR. MARTIN:—I would like to say on the gentleman's part that he speaks our language extremely well, but that he has a tremendous amount of modesty. Therefore I think he will appreciate it if we let him off this time, and tax him the more heavily at the next meeting.

Adjourned.

Reference List of Leading Authorities Cited in the Index of Current Electrical Literature.

NAME.	ABBREVIATION.	PUBLISHED, &C.
Engineer.	*Engr.*	London, 163 Strand, weekly. £1.9.
Engineering.	*Eng.*	London, 35–36 Bedford St. W, C.; weekly. £1.16.
Industries.	*Indust.*	Manchester, 70 Market St., weekly. £1.12.
The Electrician.	*Lond. Elecn.*	London, 1 Salisbury Court, E. C.; weekly. £1.2.
The Telegraphic Journal and Electrical Review.	*Lond. Elec. Rev.*	London, 22 Paternoster Row, E. C.; weekly. £1.1.8.
The Electrical Engineer	*Lond. Elec. Engr.*	London, 139–140 Salisbury Court; weekly, 17s. 4d.
Nature.	*Nat.*	London, 29 Bedford St., W. C.; weekly. £1.8.
India Rubber & Gutta Percha & Electrical Trades Journal.	*I. R. & G. P. Jour.*	London, 115 Finsbury Pavement, E. C ; monthly. 15 shillings.
The Electrical Engineer	*N. Y. Elec. Engr.*	New York, 11 Wall Street; monthly, $3
The Electrical World.	*Elec. World.*	New York, 168–177 Potter Building; weekly. $3
The Electrical Review.	*N. Y. Elec. Rev.*	New York, 13 Park Row ; weekly. $3.
The Electric Age.	*Elec. Age.*	New York, 5 Dey Street ; semi-monthly, $1.50.
Modern Light and Heat.	*Md Lt and Ht.*	Boston, 178 Devonshire St.; weekly, $3
Western Electrician.	*West. Elecn.*	Chicago, 6 Lakeside Building; weekly. $3.
Journal of the Franklin Institute.	*Jour. Fkln. Inst.*	Philadelphia, Franklin Institute; monthly, $5.
Science.	*Science.*	New York, 47 Lafayette Place, weekly, $3.50.
Scientific American.	*Sci. Am.*	New York, 361 Broadway; weekly, $3.
Scientific American Supplement.	*Sci. Am. Supp.*	New York, 361 Broadway ; weekly, $5.
Mechanics.	*Mech.*	Philadelphia, 907 Arch St.; monthly, $1.
Railroad Gazette.	*R'd. Gaz.*	New York, 73 Broadway; weekly, $4 20.
American Machinist.	*Am. Mach.*	New York, 96 Fulton St ; weekly, $2.50.
Street Railway Journal	*St. Ry. Jour.*	New York, 113 Liberty St.; monthly, $2
Street Railway Gazette.	*St. Ry. Gaz.*	Chicago, 9 Lakeside Building; monthly. $2.
Light, Heat and Power	*Lt. Ht. and Pr.*	Philadelphia, 413 Walnut Street; semi-monthly, $3.
Progressive Age.	*Prog. Age.*	Philadelphia, 333 Walnut St.; monthly, $2
Railroad and Engineering Journal.	*Rd. and Eng. Jour.*	New York, 45 Broadway; monthly, $3.
Practical Electricity.	*Prac. Elec.*	Boston, 178 Devonshire St.; monthly, $2.

—INDEX—

OF

CURRENT ELECTRICAL LITERATURE,

&c. (July, 1888.)

TELEGRAPHY.

Postal Telegraph Revenue. (Note) *Lond. Elecn.*, July 27, p. 363.

Post Office Telegraphy. *Eng.*, July 13, p. 38.

Text of the Official Instructions for the Examination of Apparatus Issued by the Postal Telegraph Department. *Lond. Elecn*, July 6, p. 276; July 13, p. 310.

Telegraph Survey and Construction. (Corr) A. E. Gilbert. *Lond Elec. Rev.*, July 20, p. 84.

Telegraph Operators in Asia. *West. Elecn.*, July 14, p. 19.

Telegraph Operators in Persia. T. Stevens. *N. Y. Sun; Lond. Elecn.*, July 27, p. 372.

Obituary. Hiram Sibley. (Ill.) *Elec. World*, July 21, p. 26.

Seventh Annual Meeting of the Association of Railway Telegraph Superintendents. *Elec. World*, July 21, p. 31; *N. Y. Elec. Rev.*, July 21, p. 6; *Md. Lt. & Ht*, July 19, p. 61; *West. Elecn.*, July 21, p. 32.

Telegraphing by the Clouds. Grubbe. *Sci. Am*, July 7, p. 2.

Spectro-Telegraphy. (Ill.) P. C. Dresing. *Elec. World*, July 21, p. 27.

Delany's Key Anticipated. (Corr.) F. Higgins. *Lond. Elecn.*, July 13, p. 322.

Delany's Electrical Bulletin Board. (Ill.) *Elec. World*, July 28, p. 38.

Automatic Circuit Closing Key. (Ill.) *West. Elecn.*, July 21, p. 26.

Combined Morse Ink Writer and Sounder. (Ill.) *Sci. Am. Supp.*, July 28, p. 10,477.

TELEPHONY.

A Great Telephone Switchboard. (Note.) *Lond. Elec. Rev.*, July 13, p. 44.

Vail and Seely's Improvements in Telephone Exchanges. (Ill.) *N. Y. Elec. Rev.* July 14, pp. 1–7.

The Radio-Microphone. C. V. Boys. *Science*, July 6, p. 7.

On Electro-Chemical Radiophony. Chaperon & Mercadier. *Comptes Rendus: Lond. Elec. Rev.*, July 13, p. 37; *Science*, July 6, p. 7; *Elec. World*, July 14, p. 15.

C. A. Bell's Water-Jet Telephone Transmitter and System of Telephonic Communication. (Ill.) G. W. de Tunzelmann. *Lond. Elecn.*, July 27, p 375; *Indust.*, July 27, p. 89.

The Graphophone. (Ill.) C. S. Tainter. *Elec. World*, July 14, p 16.

The Tainter-Bell Graphophone. (Ill.) *Indust.*, July 27, p. 76.

Phonograph and Graphophone Controlled by One Company. *West. Elecn.*, July 28, p. 39.

Edison's Phonograph in London. *West. Elecn.*, July 7, p. 1.

On Some Possible Methods for the Reproduction of Gramophone and Telephone Records. E. J. Houston, Am. Philos. Soc. *Elec. World*, July 14, p. 21.

Reproduction of Articulate Speech and other Sounds. (Ill.) *Sci. Am.*, July 14, pp. 16–23.

Introduction of the Telephone into Siam. *N. Y. Elec. Rev.*, July 14, p. 7.

Life Saving Stations to be Connected by Telephone. *N. Y. Elec. Rev.*, July 14, p. 7.

Telephones for the London Police. *N. Y. Elec. Rev.*, July 7, p. 4

Theory of Telephone Conductors. *Sci. Am. Supp.*, July 7. p 10,430.

Bell Victorious over Cushman. *West. Elecn.*, July 28, p. 38.

Practical Telephony. T. D Lockwood. *West. Elecn.*, July 7, p. 8; July 21, p. 31.

How to Use the Telephone on Submarine Cables. *Sci. Am.*, July 21, p. 37.

ELECTRIC LIGHT.

Electric Yacht Lighting. (Ill.) (Allen & Co.) *Indust.*, July 27, p. 88.

Walker's Marine Electric Lighting Plant. (Ill.) *Lond. Elec. Rev.*, July 20, p. 62; *Indust.*, July 27, p. 89.

Electrically Lighting a Ball Room Afloat. *Lond. Elec. Rev.*; *Md. Lt & Ht.*, July 5, p. 11.

The Well-Lighted "Omaha." *N. Y. Elec. Rev.*, July 14, p. 8.

The Adelphi Installation. *Lond. Elec. Engr.*, July 27, p. 80.

Some English Central Lighting Stations—Cadogan Station at Chelsea. *Lond. Elecn.*, July 20, p. 334; *Lond. Elec. Rev*, July 20, p. 65.

Incandescent Street Lighting. (Note.) *Lond. Elec. Engr.*, July 20, p. 49.

The "Sun" Miners' Electric Lamp. (Note.) *Lond. Elec. Engr.*, July 20, p 48.

Artistic Fittings. (Ill., III. Binswanger & Co. *Lond. Elec. Engr.*, July 6, p. 6.

Electric Lighting in Mines. *Science*, July 20, p. 30.

Incandescent Lamp Experiments. Mascart. *Lond. Elecn.; Science*, July 13, p. 21.

A Table of Incandescent Lamp Leads. *Elec. World*, July 14, p. 20; *Lond. Elec. Engr.*, July 27, p. 74.

Incandescent Lamps for Boiler Inspection. *Elec. World*, July 7, p. 7. (Blass.)

The Heisler Plant at Wabash, Ind. (Ill.) *Elec. World*, July 7, p. 4; *West. Elecn.*, July 7, p. 3.

Auditorium Electric Plant. *West. Elecn.*, July 28, p. 39.

Electric Light in the Chicago Opera House. *West. Elecn.*, July 14, p. 13.

A Portable Electric Lamp. (Ill.) *Sci. Am. Supp.*, July 7. p. 10,429.

Device for Cutting Lamps In or Out of Circuit. (Ill.) *West. Elecn.*, July 7, p. 2.

Electric Lighting at the Brussels Exhibition. *Lond. Elec Rev.*, July 20, p. 65.

The Cincinnati Exposition. Some of the Electrical Effects. *Md. Lt. & Ht.*, July 5, p. 10.

The New England Electric Exchange Indorsed by the Insurance Interests. *N. Y. Elec. Rev.*, July 7, p. 7.

The New England Electric Exchange. *Md. Lt. & Ht.*, July 5, p. 6; July 12, pp. 28, 29; July 19, p. 59.

The Commercial Aspect of Electric Lighting. *Sci. Am.*, July 28, p. 52.

Gas Companies and Electricity. F. W. Day. *Lond. Elec. Engr*, July 20, p. 59

Electric Switch Lights. *West. Elecn.*, July 21, p. 26.

Electric Lights for Fishing Nets. *Sci. Am.*, July 21, p. 40

The Edison Ground Detector for Electric Light Circuits. (Ill.) A. E. Kennelly. *Elec. World*, July 7, p. 6; *Lond. Elec. Rev.*, July 27, p. 92.

Danger from Electric Lighting Wires. M. Mascart. *Sci. Am.*, July 7, p. 9.

Elementary Testing Suitable for Electric Lighting Systems. T. Gray. (Ill.) Cont'd from p. 583. *Lond. Elec. Engr.*, July 13, p. 28.

Electrification of Metal Plates by Irradiation with Electric Light. Hallwachs. *Science*, July 20, p. 30.

Experiments on the Electric Arc. *Science*, July 6, p. 7.

Electric Lamp Posts. (Note.) *Lond. Elec. Engr.*, July 6, p. 4.

Night Navigation on the Suez Canal. *Indust.*, July 13, p. 44; *Md. Lt. & Ht.*, July 26, p. 85.

The Most Powerful Electric Light in the World. (Ill.) *Sci. Am. Supp.*, July 21, p. 10,455; *N. Y. Elec. Rev.*, July 14, p. 9.

A New Electric Light Mast Arm. (Ill.) (Renehan.) *Elec. World*, July 14, p. 19.

A New Focusing Lamp. (Ill.) *West. Elecn.*, July 14, p. 13.

The Anglo-American Brush Company. *Lond. Elec. Engr.*, July 20, p. 53.

The Anglo-American Brush Corporation and the Lamp Question. *Lond. Elecn.*, July 20, p. 343.

The Edison Lamp Patents in England. *N. Y. Elec. Engr.*, July, p. 314; *Indust.*, July 6, p. 14; *Eng.*, July 20, p. 63.

The Edison Patent Case in England. *Md. Lt. & Ht.*, July 26, p. 87.

Important Decisions in England. *N. Y. Elec. Rev.*, July 28, p. 4.

The Incandescent Lamp Suits in England. *Elec. World*, July 28, p. 46.

Important Electric Light Decisions in England. *Elec. World*, July 21, p. 25.

Edison and Swan United Electric Light Company Limited vs. Holland and others. *Lond. Elec. Engr.*, July 20, p. 61; *Lond. Elecn.*, July 6, p. 264; July 20, p. 344; *Lond. Elec. Rev.*, July 6, p. 9; July 20, p. 69.

Swaby vs. Watt and others. *Lond. Elec. Engr.*, July 6, p. 17.

DYNAMOS, SYSTEMS OF DISTRIBUTION, ETC.

New Thomson-Houston Dynamo. (Ill.) *N. Y. Elec. Rev.*, July 7, p. 8; *Lond. Elec. Engr.*, July 20, p. 58.

Elwell-Parker Electro-Deposition Dynamo. (Ill.) *Lond. Elec. Rev.*, July 27, p. 92; *Indust.*, July 20, p. 66.

The Baxter 100,000 Watt Generator. (Ill.) *Elec. World*, July 28, p. 39.

A Novel Combination of Engine and Dynamo. (Ill.) Holmes. *Elec. World*, July 21, p. 30.

Practice in Dynamo Construction. R. Dobbie. *Elec. World*, July 21, p. 26.

Notes on Dynamo Construction. Sidney F. Walker. *Lond. Elec. Engr.*, July 13, p. 35; July 20, p. 50; July 27, p. 72.

The Construction of Dynamo-Electric Machines. C. P. Poole. *Elec. World; Lond. Elec. Engr.*, July 13, p. 38.

Dynamo Construction. (Corr.) W. H. Eaves. *Lond. Elec. Rev.*, July 27, p. 106.

The Conditions of Regulation in Dynamos for Constant Poential. (Corr.) W. B. Esson. *Lond. Elecn.*, July 13, p 321. Guy C. Fricker. July 20, p. 350.

Improved Alternate Current Dynamo. (Mordey.) (Ill.) *Sci. Am. Supp.*, July 21, p. 10,456.

Efficiency of Dynamos. (Note.) (Fontaine.) *L'Electricien; Lond. Elec. Engr.*, July 6, p. 3.

Notes on Alternate Currents. (Ill.) J. A. Fleming. (Cont'd from p. 143.) *Lond. Elecn.*, July 20, p. 334.

New Transformers. (Note.) (Doubrava.) *Lond. Elecn.*, July 6, p. 259.

Continuous and Alternating Currents. *Science*, July 20, p. 29.

Reply to Harold P. Brown. *Md. Lt. & Ht.*, July 26, p. 88.

The Continuous Current vs. The Alternating Current. G. H. Bliss. Chic Elec. Club. *N. Y. Elec. Engr.*, July, p. 311.

The Continuous Current, Limited, vs. The Alternating Current, Unlimited. (Ill.) G. Cutter, Chic. Elec. Club. *N. Y. Elec Engr.*, July, p. 308.

The Comparative Value of the Alternating Transformer and Continuous Current System for Central Station Lighting. F. B. Badt. *N. Y. Elec. Engr.*, July, p. 305.

The Gaulard and Gibbs Patent on Secondary Generators. (Ill.) *Lond. Elecn.*, July 6, p. 263.

The Transformer Case. *Indust.; Lond. Elec. Rev.*, July 27, p. 96. (Gibbs *v.* Ferranti.)

Gaulard and Gibbs vs. Ferranti. *Lond. Elecn.*, July 6, p. 278; July 13, p. 313; *Lond. Elec. Rev.*, July 13, p. 47; *Indust.*, July 13, p. 39; July 20, p. 62.

Note on Continuous Current Transformers. S. P. Thompson, Phys. Soc. *Lond. Elec. Engr.*, July 6, p. 9; *Lond. Elecn.*, July 13, p. 318; *Indust.*, July 6, p. 18; *Eng.*, July 6, p. 6; *Lond. Elec. Rev.*, July 13, p. 51.

Working Alternators in Parallel. (Corr.) Otto T. Blathy. *Lond. Elecn.*, July 13, p. 321.

Electro-Dynamic Rotation by Alternating Currents. (Ill.) Ferraris. *Sci. Am. Supp.*, July 7, p. 10,429.

Converters in America. Prof. Forbes, Soc. Tel. Engrs. & Elecns. *West. Elecn.*, July 7, p. 1.

Unipolar Induction. V. (Ill.) G. W. de Tunzelmann. (Cont'd from p. 234.) *Lond. Elecn.*, July 6, p. 262; July 13, p. 300; July 27, pp. 365-387.

Personal Safety and High-Tension Current. Leo. Daft. (Ext. Pam. Daft E. L. Co.) *Lond. Elecn.*, July 27, p. 373.

The Admission of Alternating Currents into New York City. *Elec. World*, July 28, p. 40.

The Balancing of Rotating Bodies. (Corr.) E. F. Carpenter. *Elec. World*, July 21, p. 29. Blondel. *Elec. World*, July 21, p. 29.

Balancing Armatures. (Ill.) (Corr.) *Elec. World*, July 7, p. 8.

Balancing Moving Parts. C. Seymour. *Elec. World; Lond. Elec. Engr.*, July 20, p. 60.

Thomson's New Electric Welding Apparatus. (Ill.) *Elec. World*, July 7, p. 3; *Lond. Elec. Engr.*, July 20, p. 58.

Direct Electric Welding Machine. (Ill.) *West. Elecn.*, July 14, p. 16.

Practical Application of Electric Welding. O. K. Stewart. *Sci. Am. Supp.*, July 21, p. 10,456.

Welding Rails by Electricity. (Corr.) (Ill.) E. E. Ries. *N. Y. Elec. Engr.*, July, p. 321.

ELECTRIC POWER, ETC.

The Lugo Motor. (Ill.) *Elec. World*, July 14, p. 15; *N. Y. Elec. Rev.*, July 14, p. 2; *Lond. Elec. Engr.*, July 27, p. 78.

On the Tesla Alternating Current Motor. J. Swinburne. *Lond. Elecn.*, July 20, p. 342.

The Tesla Motor. (Corr.) P. H. Van der Weyde. *N. Y. Elec. Rev.*, July 14, p. 3.

Motors in England. *West. Elecn.*, July 21, p. 25.

Relative Displacement of a Steam Engine and an Electric Motor for the Same Work. (Ill.) *Elec. World*, July 7, p. 3.

A Problem in Alternating Current Motors. Wilkes and Hutchinson. *Elec. World*, July 21, p. 28.

The Application of Electric Motors to Mining. (Ill.) *Elec. World*, July 7, p. 7.

Note on the Governing of Electro-Motors. Ayrton and Perry, Phys. Soc. *Lond. Elec. Rev.*, July 20, p. 60.

Small Electric Motors. *Lond. Elec. Rev.*, July 27, p. 97.

Electric Launches on the Thames. *Lond. Elec. Rev.*, July 13, p. 40.

Reckenzaun's Electric Boat in America. (Note.) *Elec. World; Lond. Elec. Rev.*, July 6, p. 17; *Science*, July 6, p. 6.

An Electric Ferryboat. *N. Y. Elec. Rev.*, July 28, p. 2.

The Electric Launch. *West. Elecn.*, July 7, p. 2.

An Electric Bone Cutter. *N. Y. Elec. Rev.*, July 7, p. 10.

Pumping by Electricity. (Note.) *Lond. Elec. Rev.*, July 6, p. 18.

Electric Locomotion. (Corr.) A. Reckenzaun. *Lond. Elec. Rev.*, July 13, p. 55.

Electric Street Cars. *West. Elecn.; Sci. Am.*, July 21, p. 41.

Electrical Street Cars. *Sci. Am.*, July 14, p. 22.

The Pittsburg Electric Railway. *Lond. Elec. Engr.*, July 13, p. 41.

Inspecting the Observatory Hill Electric Road. *St. Ry. Jour.*, July, p. 173.

Cost of Electric Traction. *Lond. Elec. Rev.*, July 20, p. 75; *Science*, July 6, p. 7.

Some Electric Roads in New England. (Ill.) *Md. Lt. & Ht.*, July 19, p. 67.

The Ries Driving Connection for Electric Street Cars. (Ill.) *Md. Lt. & Ht.*, July 19, p. 65.

The Wall Street Ferry Electric Road and Elevated Terminal. (Ill.) *St. Ry. Jour.*, July, p. 169.

Advantages of Electricity for Railroad Work. *N. Y. Elec. Engr.*, July, p. 302.

Thomson-Houston Electrical Railway System. (Ill.) *West. Elecn.*, July 28, p. 37.

The Solution of Municipal Rapid Transit. (Ill.) F. J. Sprague, Am. Inst. Elec. Engrs. *West.. Elecn.*, July 21, p. 27; July 28, p. 40; *N. Y. Elec. Rev.*, July 21, pp. 2–7; *Science*, July 27, p. 45; *Elec. World Supp.*, July 21.

The Richmond Electric Road. *West. Elecn.*, July 14, p. 20.

Charters for Rapid Transit Companies. *West. Elecn.*, July 14, p. 13.

The Julien Regulating Switch for Storage Battery Cars. (Ill.) *Elec. World*, July 21, p. 27.

Electric Locomotion. C. P. Elieson. *Lond. Elec. Rev.*, July 6, p 8.

Accumulators for Tramways. (Note.) *Lond. Elec, Engr.*, July 13, p. 26.

Cost of Storage Battery Traction Reduced. (Corr.) W. Bracken. *St. Ry. Jour.*, July, p. 178.

BATTERIES, ELECTROLYSIS, ETC.

A New Constant Cell. (Note) (Fabrigi & Farkas.) *Lond. Elec. Engr.*, July 6, p. 2; *Elec. World*, July 14, p. 20.

Clark Standard Cells. (Note.) *Elec. World; Lond. Elec. Engr.*, July 6, p. 4.

Primary Batteries of Light Weight. *Eng.*, July 20, p. 68.

The Weymersch Battery. *Eng.; Sci. Am.*, July 21, p. 38; *N. Y. Elec. Rev.*, (Tests) July 14, p. 8; *Indust.*, July 6, p. 20; *Science*, July 13, p. 21.

The D'Humy Water Primary Battery. (Corr.) J. T. Browne. *Lond. Elec. Rev.*, July 27, p. 108.

The O'Keenan Primary Battery and its Application to Domestic Electric Lighting. (Ill.) A. Shedlock. *Elec. World*, July 7, p. 5.

Gravity Battery vs. Dynamos. (Corr.) *N. Y. Elec. Engr.*, July, p. 320.

Effects of Different Positive Metals, etc., Upon the Changes of Potential of Voltaic Couples. G. Gore. (Abs. Roy. Soc.) *Lond. Elec. Rev.*, July 6, p. 14; *Sci. Am. Supp.*, July 28, p. 10,476.

Influence of the Chemical Energy of Electrolytes Upon the Minimum Point of Change of Potential of a Voltaic Couple in Water. G. Gore. (Roy. Soc.) *Lond. Elecn.*, July 27, p. 378; *Lond. Elec. Rev.*, July 13, p. 38; *Eng.*, July 20, p. 73; *Sci. Am. Supp.*, July 28, p. 10,476.

On the Change of Potential of a Voltaic Couple by Variation of Strength of its Liquid. G. Gore. (Abs. Roy. Soc.) *Lond. Elec. Rev.*, July 13, p. 37.

Effect of Different Positive Metals, etc., Upon the Changes of Potential of Voltaic Couples. G. Gore. (Roy. Soc.) *Elec. World*, July 14, p. 21.

Alternate-Current Electrolysis. (Ill.) Ayrton & Perry. *Lond. Elecn.*, July 13, p. 299.

Electrolysis by Alternate Currents. (Note.) Maneuvrier & J. Chappuis. *Lond. Elec. Engr.*, July 27, p. 69.

Practical Notes Concerning the Construction, Use and Management of Storage Batteries. A. Reckenzaun. (Cont'd from p. 666.) *Lond. Elec. Rev.*, July 6, p. 7; July 13, p. 36.

Apparatus for Storage Battery Work. (Ill.) *N. Y. Elec. Rev.*, July 21, p. 1.

Appliances for Storage Batteries. *N. Y. Elec. Rev.*, July 28, p. 10.

The Gibson Storage Battery. (Ill.) *Elec. World*, July 7, p. 7.

Electric Storage. P. Atkinson. *West. Elecn.*, July 7, p. 3.

INSTRUMENTS, MEASUREMENTS, ETC.

The Voltaic Balance. G. Gore. *Lond. Elec. Rev.*, July 6, p. 14; *Lond. Elecn.*, July 20, p. 337.

A Bureau of Electrical Testing. *Baltimore Sun; N. Y. Elec. Rev.*, July 28, p. 3. (Johns Hopkins University.)

Laboratory Testing Stand. (Note.) *The Engr.; Lond. Elec. Engr.*, July 20, p. 48.

Discussion of the Precision of Measurements. S. W. Holman. *Tech. Quarterly.; N. Y. Elec. Engr.*, July, p. 294.

Portable Mercurial Barometer. Blakesley. (Phys. Soc.) *Indust.*, July 6, p. 19; *Lond. Elec. Rev.*, July 13, p. 52.

Stephen's Electrical Barometer. (Ill.) *Elec. World*, July 14, p. 18.

A Study of Certain Errors in the Constant Shunt Method. W. L. Puffer. Am. Acad. Arts and Sciences. *Lond. Elec. Engr.*, July 6, p. 15; July 13, p. 39; *N. Y. Elec. Engr.*, July, p. 291.

Mr. Vernon Harcourt's New Photometer. (Ill.) *Lond. Elec. Rev.*, July 13, p. 39; *Lond. Elec. Engr.; Md. Lt. & Ht.*, July 5, p. 13.

Comparing Very Unequal Capacities. (Corr.) Ayrton & Perry. *Lond. Elec. Rev.*, July 20, p. 82.

Comparing Very Unequal Capacities. (Ill. Corr.) A. A. Voysey. *Lond. Elec. Rev.*, July 6, p. 26. J. Pigg. July 13, p. 54.

The Hicks Glass-Bead Hydrometer. (Ill.) *Lond. Elecn.*, July 27, p. 384.

The Photometry of Color. Capt. Abney. (Phys. Soc.) *Lond. Elec. Rev.*, July 13, p. 51.

Determination of the Ohm by Lippmann's Electro-Dynamic Method. M. H. Wuilleumier. *Lond. Elec. Rev.*, July 13, p. 41.

Sir William Thomson's New Standard Electrical Measuring Instruments. (Ill.) Soc. Tel. Engrs. and Elecns. *Lond. Elecn.*, July 27, p. 368.

Sir William Thomson's Composite Electric Balance. (Ill.) T. Gray. *West. Elecn.*, July. 14, p. 14; *Sci. Am. Supp.*, July 14, p. 10,445.

UNDERGROUND WIRES, ETC.

Protecting Underground Conductors. (Ill.) (Corr.) David Brooks. *Lond. Elec. Rev.*, July 6, p. 26.

Underground Electric Light Wires. *Science*, July 13, p. 22.

An Argument in Favor of Underground Wires. (Corr.) B. E. Sunny. *N. Y. Elec. Rev.*, July 7, p. 5; *Lond. Elec. Rev.*, July 27, p. 95.

Successful Underground Arc Light Circuits. (Corr.) B. E. Sunny. *West. Elecn.*, July 7, p. 9.

More Information Touching Underground Matters and Alternating Currents brought out at Meeting of Board of Electrical Control. (Ill.) *N. Y. Elec. Rev.*, July 28, p. 7.

Underground Electric Wires. (Morton.) *N. Y. Elec. Rev.*, July 21, p. 1.

President Lynch gives his Reasons for not Using the Conduits. *N. Y. Elec. Rev.*, July 14, p. 9.

Irish's Conduit for Electric Wires. (Ill.) *West. Elecn.*, July 28, p. 28.

Detecting Leaks in Underground Conductors. E. A. Scott. *Elec. World*, July 28, p. 39.

Overhead Wires. W. A. Anthony, N. Y. Elec. Club. *Md. Lt. & Ht.*, July 5, p. 7; *N. Y. Elec. Rev.*, July 7, p. 2, p. 8.

American Institute of Electrical Engineers. (G. W. Plympton's Paper.) *West. Elecn.*, July 7, pp. 5, 7.

MECHANICAL, ETC.

High and Slow Speed Engines (Ill.) J. A. Powers. *N. Y. Elec. Engr.*, July, p. 289; *Lond. Elecn.*, July 20, p. 337.

The Curtis Combined Steam Separator and Trap. (Ill.) *Elec. World*, July 21, p. 30.

Notes on Belts and Belt Driving. J. N. Cooper. Soc. Tel. Engrs.; *Lond. Elec. Engr.*, July 6, p. 7.

Nominal Horse-Power. (Note.) *Lond. Elec. Engr.*, July 13, p. 27.

Fuel Testing. *Lond. Elec. Engr.*, July 27, p. 70.

The Beaumont Epicyconoidal Gear. (Ill.) T. Arnall. *Lond. Elecn.*, July 27, p. 387.

On an Optical Model. A. W. Rucker. (Phys. Soc.) *Lond. Elec. Rev.*, July 13, p. 51.

A New Feed Water Heater. (Ill.) (Hussey.) *N. Y. Elec. Rev.*, July 28, p. 3; *Md. Lt. & Ht.*, July 26, p. 86.

MISCELLANEOUS.

The Moebius Electric Process for Refining Silver. *N. Y. Elec. Rev.*, July 14, p. 1.

De Bausset's Air Ship. *N. Y. Sun; West. Elecn.*, July 21, p. 26.

An Electric Speed Recorder. G. H. Barrus. *West. Elecn.*, July 14, p. 19.

The Electric Spider. (Ill.) *Sci. Am. Supp.*, July 7, p. 10,430.

A New Automatic Register. (Ill.) *N. Y. Elec. Rev.*, July 28, p. 6.

Electrostatic Transformers. *Electrotechnische Anzeiger; Elec. World*, July 21, p. 26.

Compensated Resistance Coils. J. Swinburne. *Elec. World*, July 21, p. 26.

Delany's Safety Device for Linemen. C. W. S. Crawley & H. Nalder. *Lond. Elecn.; Elec. World*, July 7, p. 8.

Villiers-Stead and Hageman's Electrical Automatic Delivery Box. (Ill.) *Lond. Elec. Rev.*, July 13, p. 35.

Electric Firing. (Note.) *Colliery Guardian; Lond. Elec. Engr.*, July 20, p. 46.

Detector for Hot Bearings. (Ill.) *Lond. Elec. Engr.*, July 13, p. 37.

Weber and Schefbauer's Insulation. (Note.) *Lond. Elec. Engr.*, July 6, p. 2.

A New Insulating Material. *Chronique Industrielle; Indust.*, July 20, p. 67; July 27, p. 91.

A Magnetic Hook. *Eng.*, July 20, p. 68.

Wilkes' Pole Indicator. (Note.) *Indust.*, July 27, p. 91.

Some New Electrical Appliances. (Ill.) *Md. Lt. & Ht.*, July 26, p. 90. (Redding Elec. Co.)

Trouve's Anxanoscope. (Ill.) *L'Electricien; N. Y. Elec. Engr.*, July, p. 300.

Automatic Ground Switch. (Ill.) *N. Y. Elec. Rev.*, July 14, p. 8; *Elec. World*, July 14, p. 19; *West. Elecn.*, July 14, p. 15.

Hedge's Patent Double Pole Switch. (Ill.) *Lond. Elec. Rev.*, July 20, p. 60.

Double Pole Instantaneous Break Switch. (Ill.) *Lond. Elec. Rev.*, July 27, p. 101.

An Electric Deep-Sea Sounding Instrument. (Note.) Cooper & Wigzell. *Lond. Elec. Rev*, July 20, p. 74.

The Glaeser Influence Machine. *Elec. World* July 14, p. 14.

A New Influence Machine. (Ill.) *Sci. Am. Supp.*, July 7, p. 10,430.

The Burton Electric Heater. *N. Y. Elec. Rev*, July 28, p. 1.

Heat from Electricity. *West. Elecn.*, July 28, p. 39

Fire Alarm Signal Box. (Ill) *West. Elecn.*, July 21, p 26.

Automatic Electric Train-Starter. (Ill.) *Md. Lt. & Ht.*, July 5, p. 12.

Electric Level-Crossing Signals. (Note) Folks. *Lond. Elec. Engr.*, July 27, p. 68.

New Annunciator and Help Call. (Ill.) *N. Y. Elec. Rev.* July 28, p 1.

Electric Signals for Army Scouts. *N. Y. Elec. Rev.*, July 28, p. 1.

An Improved Electrical Annunciator. (Ill) Downerd. *Sci. Am*, July 14, p. 18.

A Magneto-Electric Watchman's Clock. (Ill) *Md. Lt. & Ht.*, July 12, p. 39.

An Improved Magneto Call Bell. *Lond. Elec. Rev.*, July 20, p. 65.

The Electrical Distribution of Time. Allen D. Brown. *Proc. Fkln. Inst; Lond. Elec. Engr.*, July 27, p. 82.

Hahn's Time Detector for Watchmen. *Indust.*, July 6 p. 1.

Electric Light Signals for Use at Sea. (Note.) (Bechler.) *Lond. Elec. Engr.*, July 13, p. 25.

Okonite Conductors. *Lond. Elec. Rev.; West. Elecn.*, July 28, p. 43.

Okonite Wire in England. *Elec. World*, July 7, p. 4.

Weston's New Alloys for Electric Conductors. *Elec. World*, July 28, p 39.

The Relative Merits of Iron and Lead Covering for Cables. David Brooks. *Elec. World*, July 14, p. 19; *Lond. Elec. Engr.*, July 27, p. 74.

Lead-Covered Cables. (Note.) *Lond. Elec. Rev.*, July 13, p. 46.

Shaw and Connolly's Conductors. (Note.) *Lond. Elec. Rev.*, July 20, p. 75.

Magnetism in Watches. O. Ericsson. *Elec. World*, July 14, p. 19; *N. Y. Elec. Rev.*, July 28, p. 10.

Aerial Photography. *West. Elecn.*, July 14, p. 17

Photographing Lightning. (Ill.) L. W. Serrell, Jr. *Elec. World*, July 14, p. 14.

Lightning in an Electric Installation. (Corr.) Ernst Fahrig. *Lond. Elecn*, July 20, p. 351.

Protection of Buildings from Lightning. (Ill.) Oliver Lodge. Cont'd from p. 236. *Lond. Elecn.*, July 6, p. 273; July 13, p. 302. (Corr.) p. 303.

Death by Lightning. *Md. Lt. & Ht.*, July 26, p. 85.

Lightning Arresters and Lightning Rods. *Md. Lt. & Ht.*, July 12, p. 28.

Lightning. (Ill.) S. A. Varley. *Lond. Elec. Rev.*, July 20, p 66; July 27, p. 88.

Death by Electricity. *Sci. Am.*, July 14, p. 26; *Lond Elec. Rev.*, July 13, p. 32.

Electric Execution. (Note on Edison's Plan.) *Sci. Am. Supp.*, July 21, p. 10,457.

On Death by Electricity. E. J. Houston. *Lond. Elec. Rev.*, July 13, p. 34.

Electric Killing. *Lond. Elecn.; Md. Lt. & Ht.*, July 19, p. 58.

The Influence of the Condenser on Disruptive Discharges. (Ill.) E. G. Acheson. *Elec. World*, July 7, p. 2; *N. Y. Elec. Rev.*, July 7, p. 9; *Lond. Elec. Engr.*, July 27, p. 80.

New York Board of Electrical Control. *Md. Lt. & Ht.*, July 19, p. 16; *West. Elecn.*, July 28, pp. 43–45.

The Electric Resistance of Copper at Low Temperatures. Wroblewski. *Sci. Am.*, July 14, p. 17.

How the Convention News was Sent. *Lond. Elec. Rev.*, July 7, p 6.

What is Electricity? A. E. Dolbear. *N. Y. Elec. Rev.*, July 28, p. 2.

Potential Geometry. I. (Ill.) Townsend Wolcott. *Elec. World*, June 21, p. 29.

Experiments on Soap Bubbles and Electricity. C. V. Boys. *Elec. World*, July 21, p. 26.

The Breaking of Armature Wires. (Corr.) Royce & Co. *Lond. Elec. Rev.*, July 13, p. 56.

Light into Sound. (Corr.) J. Palmer. *Lond. Elec. Rev.*, July 13, p. 51.

On the Existence of an Undulatory Movement Accompanying the Electric Spark. E. H. Cook, Phys. Soc. *Lond. Elec. Engr.*, July 6, p. 9; *Lond. Elecn.*, July 13, p. 319; *Indust.*, July 6, p. 6; *Lond. Elec. Rev.*, July 13, p. 52.

The British Association of Medical Electricians. (Corr.) R. J. Parkes. *Lond. Elec. Rev.*, July 6, p. 28.

South Kensington. Examination of the Science and Art Department. (Ill.) *Lond. Elecn.*, July 27, p. 382.

Conductivity and the Atomic Theory. W. P. Granville. *Lond. Elecn.* July 27, p. 381.

The Volta Prize and the Inventions of M. Gramme. (Note.) *Lond. Elecn.*, July 27, p. 364.

Earth Current and Magnetic Observations at Greenwich. (Note.) *Lond. Elecn.*, July 6, p. 261.

Letters for Learners and Unprofessional Readers. (Ill.) H. D. Wilkinson. *Lond. Elecn.*, July 13, p. 306; July 27, p. 367.

Aeration Currents. Dr. Wright & C. Thompson. *Lond. Elec. Engr.*, July 20, p. 59.

Resistance at Low Temperatures. (Note.) (Wroblewski.) *Eng.; Science*, July 13, p. 21. *Lond. Elec. Engr.*, July 13, p. 26.

Magnetic Perpetual Motion. *Lond. Elec. Engr.*, July 6, p. 4.

Electrical Engineers. I. Messrs. R. E. Crompton & Co. *Lond. Elec. Engr.*, July 20, p. 57; July 27, p. 73.

The Magnetic Qualities of Nickel. J. A Ewing. (Roy. Soc.) *Lond Elecn.*, July 13 p. 307.

Elliptic Polarisation of Light in Passing through Uniaxial Crystals. Rücker, Phys. Soc. *Indust.*, July 6, p. 19.

The Electromotive Force of Magnetization. (Ill.) Nichols & Franklin *N. Y. Elec Engr.*, July, p. 303.

Action of a Current of Air and of Illumination Upon the Electric Strata which Cover Conductive Bodies. (Note.) Bichat & Blondlot. *Lond. Elec. Rev.*, July 20, p. 75.

A Monument to Electricity. (Ill.) (T. A. Edison's Laboratory.) *N. Y. Elec. Rev.*, July 7, p. 1.

The London Chamber of Commerce. *Lond. Elecn*, July 27, p. 379.

The Arc Works, Chelmsford. *Lond. Elec. Rev.*, July 20, p. 63.

Messrs. Crompton & Co.'s Works at Chelmsford. *Lond. Elecn.*, July 20, p. 344.

Peter Robinson's. *Lond. Elec. Engr.*, July 13, p. 31.

Mr. J. W. Swan's Garden Party. (Ill.) *Lond. Elec. Engr.*, July 6, p. 12.

Royal Agricultural Society's Show, Nottingham. (Ill.) *Lond. Elec. Engr.*, July 13, p. 34: July 20, p. 52; *Lond. Elecn.* (Note.) July 13, p. 296.

The Copenhagen Exhibition. (Ill.) *Lond. Elec. Rev.*, July 13, p. 33.

Glasgow International Exhibition. *Indust.*, July 6, p. 2; July 20, p. 49.

An Electrical Section to the London Chamber of Commerce. *Lond. Elec. Rev.*, July 20, p. 75; *Indust.*, July 27, p. 86.

A Trade Association. (Corr.) E. Garcke. *Lond. Elec. Rev.*, July 20, p. 83.

The Chelsea Electricity Supply Company. *Lond. Elec. Rev.*, July 20, p. 68.

Transactions of the Institute Already Published.

Vol. I. 1884.

Electrical Primer. Notes on Phenomena in Incandescent Lamps.—(Illustrated.) Prof. Edwin J. Houston of Philadelphia.—Underground Wires. (Illustrated.) W. M. Calkins of New York.—Electrical Measurements. Prof. Edwin J. Houston of Philadelphia.—The Daniell Accumulator Multiplex System of Telegraphy. (Illustrated.) Prof. Edwin J. Houston of Philadelphia.—The Electric City System. (Illustrated.) Col. Reginald H. Rinaldo of New York.—An Experimental Test Showing the Effects of Stopping the Dynamo Machine. By Prof. C. F. Brush, of Princeton, N. J.—Earth Wires; or, the Earth as an Electric Circuit Completer. (Illustrated.) D. Lowry, of Boston, Mass.—Telegraphing Without Wires—An Experiment. (Illustrated.) S. J. M. Bell.—Photometry of the Carbon Filament. Edward P. Thompson, of New York.—Describing Watt or Volt Curves. Prof. Edwin J. Houston of Philadelphia.—The Patent Office; its Relation to Inventors and to Manufacturers. C. J. Elster, late of New York.

Vol. II. 1885.

The Protection of Electrical Inventions. F. Jenks, of Washington, D. C.—Cost of Mixed Lighting. Frank P. Ellis, now of Minneapolis, Minn.—The Electric Arc Lamp Functional Clutch. (Illustrated.) By Edward P. Thompson, of New York.—Description of a Large Secondary Battery Plant for General Commercial Distribution. E. P. Thompson, of Cheyenne, Wyo.—Dolbear's System of Fac-Simile Telegraphy. (Illustrated.) Prof. Edwin J. Houston of Philadelphia.

Vol. III. 1886.

Underground Electrical Systems. By Sidney F. Shelbourne.—The Great Tangent Galvanometer of the Cornell University. Prof. W. A. Anthony, now of Manchester, Conn.—Some Recent Advances in Telephony. (Illustrated.) Thomas D. Lockwood, of Boston, Mass.—The Patent Office and Patent Office Practice. A. C. Fowler, of New York.—Static Dynamometer or Telegraph Gauge. E. W. Jones of New York. Containing a Synopsis, with references to the Articles Analyzed for Information Relative to Overhead Wires Exclusively.—Secondary Batteries for Light and Power. By A. H. Babcock.—The Wire Gauges. Report of Committee.—Notes on Hysteric Inductor. Sidney F. Shelbourne.

Vol. IV. 1887.

Electric Street Cars. T. C. Martin, of New York.—The Practical Requirements of Small Motors. E. R. Weaver, of New York.—Distribution of Electricity by Secondary Generators. (Illustrated.) By F. L. Pope, Dr. Otto Mohr, Geneva, O. E. Hildreth, Prof. Elihu Thomson and Messrs. Stanley & Shelton.—Electric Railways. E. P. Roberts, of New York.—Difference in Temperature Coefficients of the Different Coils of a Fine Resistance. Prof. W. A. Anthony, now of Manchester, Conn.—On the best Ratio of the Sections of the Grooved Armature to the Section of the Field Magnets. (Illustrated.) Joseph C. Jackson, now of Omaha.—Electric Railways and Power. By Alfred Stone. (Illustrated.) Prof. Elihu Thomson and Leo Daft.—Electric Railways. Comparative Statistics of Electric Railways. T. C. Martin, of New York.—Cable Railways. (Illustrated.) Alfred Stone, of Cleveland, O.—Electric Power, of Troy, New York.—The Two Classes under Heading VI. Position of the Trolley.—Some Conditions of Good Carbon Filaments. (Illustrated.) Prof. W. A. Anthony, of Manchester, Conn.—Lead Encased Conductors. (Illustrated.) David Brooks, of Philadelphia.—The Electric Lighting of Passenger Trains. (Illustrated.) Geo. W. Hodges, of Boston.

Vol. V. 1887-8

On Electric Supply Cars, with Special Reference to Methods of Charging. Anthony Reckenzaun, of London. Pg. 1, October, 1887.—A Cooling System, an Instrument for Measuring the Conductivity of Electricity. (Illustrated.) Prof. George Forbes, F.R.S., of London.—Electric Arc Lamp Regulators. (Illustrated.) Prof. Edwin J. Houston, of Philadelphia.—Automatic Interruption or Apparatus for Obtain Carbons. (Illustrated.) Prof. W. A. Anthony, now of Manchester, Conn.—Electric Railways. Comparative Statistics of Electric Railways. T. C. Martin, of New York.—Electric Railways. (Illustrated.) Alfred Stone, of Cleveland, O.—Electric Power, of Troy, New York.—Report of Committee on Electric Lighting. Edward P. Thompson, of New York.—Electric Lighting Without Belts. (Illustrated.) Prof. Elihu Thomson and Messrs. Stanley & Shelton.—Electric Lighting Current Selector System. (Illustrated.) Prof. Elihu Thomson and Messrs. Stanley & Shelton.—Electric Lighting. Report of Committee on Electric Lighting. Edward P. Thompson, of New York

"Every man is a debtor to his profession, from the which, as men do of course seek to receive countenance and profit, so ought they of duty to endeavour themselves by way of amends to be a help thereunto."

LORD BACON.